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# **A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley**

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Henry Langston, and Thomas Foti

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**ABSTRACT:** The Hydrogeomorphic (HGM) Approach is a method for developing and applying indices for the site-specific assessment of wetland functions. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the design of wetland restoration projects, and management of wetlands.

This Regional Guidebook presents the HGM Approach for assessing the functions of most of the wetlands that occur in the Delta Region of Arkansas, which is part of the Lower Mississippi River Alluvial Valley. The report begins with an overview of the HGM Approach and then classifies and characterizes the principal wetlands that have been identified within the Delta Region of Arkansas. Detailed HGM assessment models and protocols are presented for six of those wetland types, or subclasses, representing all of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Flat, Mid-gradient Riverine, Low-gradient Riverine Backwater, Low-gradient Riverine Overbank, Headwater Depression, Isolated Depression, and Connected Depression. For each wetland subclass, the guidebook presents (a) the rationale used to select the wetland functions considered in the assessment process, (b) the rationale used to select assessment model variables, (c) the rationale used to develop assessment models, and (d) the functional index calibration curves developed from reference wetlands that are used in the assessment models. The guidebook outlines an assessment protocol for using the model variables and functional indices to assess each of the wetland subclasses. The appendices provide field data collection forms, spreadsheets for making calculations, and a variety of supporting spatial data intended for use in the context of a Geographic Information System.

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# Assessing Wetland Functions

## *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley (ERDC/EL TR-04-16)*

**ISSUE:** Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill material in the "waters of the United States." As part of the permit review process, the impact of discharging dredged or fill material on wetland functions must be assessed. On 16 August 1996, a National Action Plan to Implement the Hydrogeomorphic Approach (NAP) for developing Regional Guidebooks to assess wetland functions was published. This report is one of a series of Regional Guidebooks that will be published in accordance with the National Action Plan.

**RESEARCH OBJECTIVE:** The objective of this research was to develop a Regional Guidebook for assessing the functions of forested wetlands in the Delta Region of Arkansas, Lower Mississippi River Alluvial Valley.

**SUMMARY:** The Hydrogeomorphic (HGM) Approach is a collection of concepts and methods for developing functional indices and subsequently using them to assess the capacity of a

wetland to perform functions relative to similar wetlands in a region. The Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review sequence to consider alternatives, minimize impacts, assess unavoidable project impacts, determine mitigation requirements, and monitor the success of mitigation projects. However, a variety of other potential applications for the Approach have been identified, including: determining minimal effects under the Food Security Act, designing mitigation projects, and managing wetlands.

**AVAILABILITY OF REPORT:** The report is available at the following Web sites: <http://www.wes.army.mil/el/wetlands/wlpubs.html> or <http://libweb.wes.army.mil/index.htm>. The report is also available on Interlibrary Loan Service from the U.S. Army Engineer Research and Development Center (ERDC) <http://libweb.wes.army.mil/lib/library.htm>.

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# Preface

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This Regional Guidebook was developed as a cooperative effort between the Arkansas Multi-Agency Wetland Planning Team (MAWPT) and Region 6 of the U.S. Environmental Protection Agency, which provided funding through the Wetland Grants 104(b)(3) program for States, Tribes, and Local Governments. Dr. Charles V. Klimas (Charles Klimas and Associates, Inc.) directed the field studies and prepared the guidebook manuscript, under contract to the Arkansas Game and Fish Commission MAWPT Coordination Office. Ms. Elizabeth O. Murray (MAWPT Coordinator, Arkansas Game and Fish Commission) prepared most of the figures. All of the persons listed as authors of this guidebook were involved in every aspect of the project, including classification, field sampling, and model testing, and otherwise contributed materially to production of the document. The affiliations of the other authors are as follows: Mr. Thomas Foti (Arkansas Natural Heritage Commission), Mr. Jody Pagan (Natural Resources Conservation Service), and Dr. Henry Langston (Arkansas State Highway and Transportation Department). Other representatives of the MAWPT member agencies provided technical oversight for the project and, together with other organizations, participated in the field studies and workshops that produced the wetland classification system, community characterizations, and assessment models used in this document. D. J. Klimas archived and summarized the field data and generated the data summary graphs in this report.

Participants in this project included representatives of federal agencies (U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, Natural Resources Conservation Service), Arkansas state agencies (Arkansas Natural Heritage Commission, Arkansas Game and Fish Commission, Arkansas Soil and Water Conservation Commission, Arkansas State Highway and Transportation Department, Arkansas Forestry Commission, Arkansas Department of Environmental Quality, and University of Arkansas Cooperative Extension Service), state university personnel, and private sector representatives. All of the individuals involved are too numerous to list here, but some people contributed a particularly large amount of time and effort: Ken Brazil (Arkansas Soil and Water Conservation Commission), Rob Holbrook (Arkansas Game and Fish Commission), Joe Krystofik (formerly of Soil and Water Conservation Commission, currently with U.S. Fish and Wildlife Service), Gary Tucker (FTN Associates, Ltd.), Phillip Moore (Arkansas State Highway and Transportation Department), Jeff Raasch (formerly MAWPT Coordinator, Arkansas Game and Fish Commission, currently with Texas Parks and Wildlife), Bill Richardson (Arkansas State Highway and Transportation Department), and Theo Wittsell (Arkansas Natural Heritage Commission). Ken Brazil, Tom Foti, Elizabeth

Murray, and Jeff Raasch provided administrative continuity and coordination among participating and funding agencies, in addition to their direct technical participation.

This report was prepared in accordance with guidelines established by the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS. It is published by ERDC as part of the Hydrogeomorphic (HGM) Guidebook series issued under the Ecosystem Management and Restoration Research Project (EMRRP). Mr. Chris V. Noble, Wetlands and Coastal Ecology Branch, Ecosystem Evaluation and Engineering Division, Environmental Laboratory (EL), ERDC, reviewed the report for consistency with HGM guidelines. In addition, the methods and protocols used to prepare this report were closely coordinated with a study simultaneously undertaken in the Delta Region of Mississippi (the Yazoo Basin). Therefore, portions of the text and some figures are similar or identical to sections of the Yazoo Basin Guidebook ("A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Selected Regional Wetland Subclasses, Yazoo Basin, Lower Mississippi River Alluvial Valley," by R. D. Smith and C. V. Klimas, ERDC/EL TR-02-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS). Note also that the Western Kentucky Regional Guidebook ("A Regional Guidebook for Assessing the Functions of Low Gradient, Riverine Wetlands of Western Kentucky," by W. B. Ainslie et al. 1999, Technical Report WRP-DE-17, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS) served as a template for the development of both this and the Yazoo Basin document. Parts of the discussion in the Western Kentucky document are included here without significant modification, particularly portions of the wildlife section (originally developed by Tom Roberts, Tennessee Technological University) and basic information on the HGM Approach and wetland functions (originally developed by R. Daniel Smith, EL). Many aspects of the classification system, field methods, and guidebook structure used here were based on reconnaissance studies in the Yazoo Basin and the Arkansas Delta conducted by Charles Klimas and R. Daniel Smith prior to initiation of this project.



# 1 Introduction

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The Hydrogeomorphic (HGM) Approach is a method for developing functional indices and the protocols used to apply these indices to the assessment of wetland functions at a site-specific scale. The HGM Approach initially was designed to be used in the context of the Clean Water Act, Section 404 Regulatory Program, to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the determination of minimal effects under the Food Security Act, design of wetland restoration projects, and management of wetlands.

In the HGM Approach, the functional indices and assessment protocols used to assess a specific type of wetland in a specific geographic region are published in a document referred to as a Regional Guidebook. Guidelines for developing Regional Guidebooks were published in the National Action Plan (National Interagency Implementation Team 1996) developed cooperatively by the U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Federal Highway Administration (FHWA), and U.S. Fish and Wildlife Service (USFWS). The Action Plan, available online at <http://www.epa.gov/OWOW/wetlands/science/hgm.html>, outlines a strategy for developing Regional Guidebooks throughout the United States, provides guidelines and a specific set of tasks required to develop a Regional Guidebook under the HGM Approach, and solicits the cooperation and participation of Federal, State, and local agencies, academia, and the private sector.

This report is a Regional Guidebook developed for assessing the most common types of wetlands that occur in the Delta Region of Arkansas in the Lower Mississippi River Alluvial Valley in the United States. Normally, a Regional Guidebook focuses on a single regional wetland subclass (the term for wetland types in HGM terminology); however, a different approach has been employed in this Regional Guidebook: multiple regional wetland subclasses are considered. The rationale for this approach is that the Lower Mississippi River and its tributaries have created a complex landscape that supports a variety of interspersed wetland types in the Delta Region of Arkansas specifically and the Lower Mississippi River Alluvial Valley generally. Subtle differences in terrain and water movement result in distinctly different functions being performed by wetlands that are in close proximity to or contiguous with one another. Further, massive flood control and drainage works instituted in the twentieth century have

dramatically affected nearly all of the wetlands in the Lower Mississippi River Alluvial Valley. Because these wetland systems have closely related origins, and have been universally influenced by flood protection and drainage efforts, it is most sensible to deal with their classification and assessment in a single integrated Regional Guidebook. This does not mean that wetlands of different hydrogeomorphic classes and regional wetland subclasses are lumped for assessment purposes, but rather that the factors influencing their functions and the indicators employed in their evaluation are best developed and presented in a unified manner. Therefore, this Regional Guidebook was developed for multiple regional wetland subclasses that commonly occur together in a subbasin. It is expected that the classification of regional wetland subclasses, assessment variables, and the assessment models developed for the Delta Region of Arkansas will have general applicability in other subbasins of the Lower Mississippi River Alluvial Valley. However, development of Regional Guidebooks for other subbasins will require collection of additional reference data that reflect regional variation in wetland characteristics within a particular subbasin.

This Regional Guidebook addresses various objectives:

- To characterize selected regional wetland subclasses in the Delta Region of Arkansas within the Lower Mississippi River Alluvial Valley.
- To present the rationale used to select functions to be assessed in these regional subclasses.
- To present the rationale used to select assessment variables and metrics.
- To present the rationale used to develop assessment models.
- To describe the protocols for applying the functional indices to the assessment of wetland functions.

This report is organized in the following manner. Chapter 1 provides the background, objectives, and organization of the document. Chapter 2 provides a brief overview of the major components of the HGM Approach, including the procedures recommended for development and application of Regional Guidebooks. Chapter 3 characterizes the regional wetland subclasses in the Delta Region of Arkansas included in this guidebook. Chapter 4 discusses the wetland functions, assessment variables, and functional indices used in the guidebook from a generic perspective. Chapter 5 applies the assessment models to specific regional wetland subclasses and defines the relationship of assessment variables to reference data. Chapter 6 outlines the assessment protocol for conducting a functional assessment of regional wetland subclasses in the Delta Region of Arkansas. Appendix A presents preliminary project documentation and field sampling guidance. Field data forms are presented in Appendix B. Appendix C contains alternate field forms, and Appendix D contains demonstration printouts of calculation spreadsheets. Common and scientific names of plant species referenced in the text and data forms are listed in Appendix E.

While it is possible to assess the functions of selected regional wetland subclasses in the Delta Region of Arkansas using only the information contained in Chapter 6 and the appendices, it is strongly suggested that, prior to conducting an assessment, users also familiarize themselves with the information and documentation provided in Chapters 2-5.

## **2 Overview of the Hydrogeomorphic Approach**

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### **Development and Application Phases**

The HGM Approach consists of four components: (a) the HGM classification, (b) reference wetlands, (c) assessment variables and assessment models from which functional indices are derived, and (d) assessment protocols. The HGM Approach is conducted in two phases. An interdisciplinary Assessment Team of experts carries out the Development Phase of the HGM Approach. The task of the Assessment Team is to develop and integrate the classification, reference wetland information, assessment variables, models, and protocols of the HGM Approach into a Regional Guidebook (Figure 1).

In developing a Regional Guidebook, the team completes the tasks outlined in the National Action Plan (National Interagency Implementation Team 1996). After the team is organized and trained, its first task is to classify the wetlands of the region of interest into regional wetland subclasses using the principles and criteria of Hydrogeomorphic Classification (Brinson 1993a; Smith et al. 1995). Next, focusing on a specific regional wetland subclass, the team develops an ecological characterization or functional profile of the subclass. The Assessment Team then identifies the important wetland functions, conceptualizes assessment models, identifies assessment variables to represent the characteristics and processes that influence each function, and defines metrics for quantifying assessment variables. Next, reference wetlands are identified to represent the range of variability exhibited by the regional subclass, and field data are collected and used to calibrate assessment variables and indices resulting from assessment models. Finally, the team develops the assessment protocols necessary for regulators, managers, consultants, and other end users to apply the indices to the assessment of wetland functions in the context of 404 Permit review.

During the Application Phase, the assessment variables, models, and protocols are used to assess wetland functions. This involves two steps. The first is to apply the assessment protocols outlined in the Regional Guidebook to complete the following tasks:

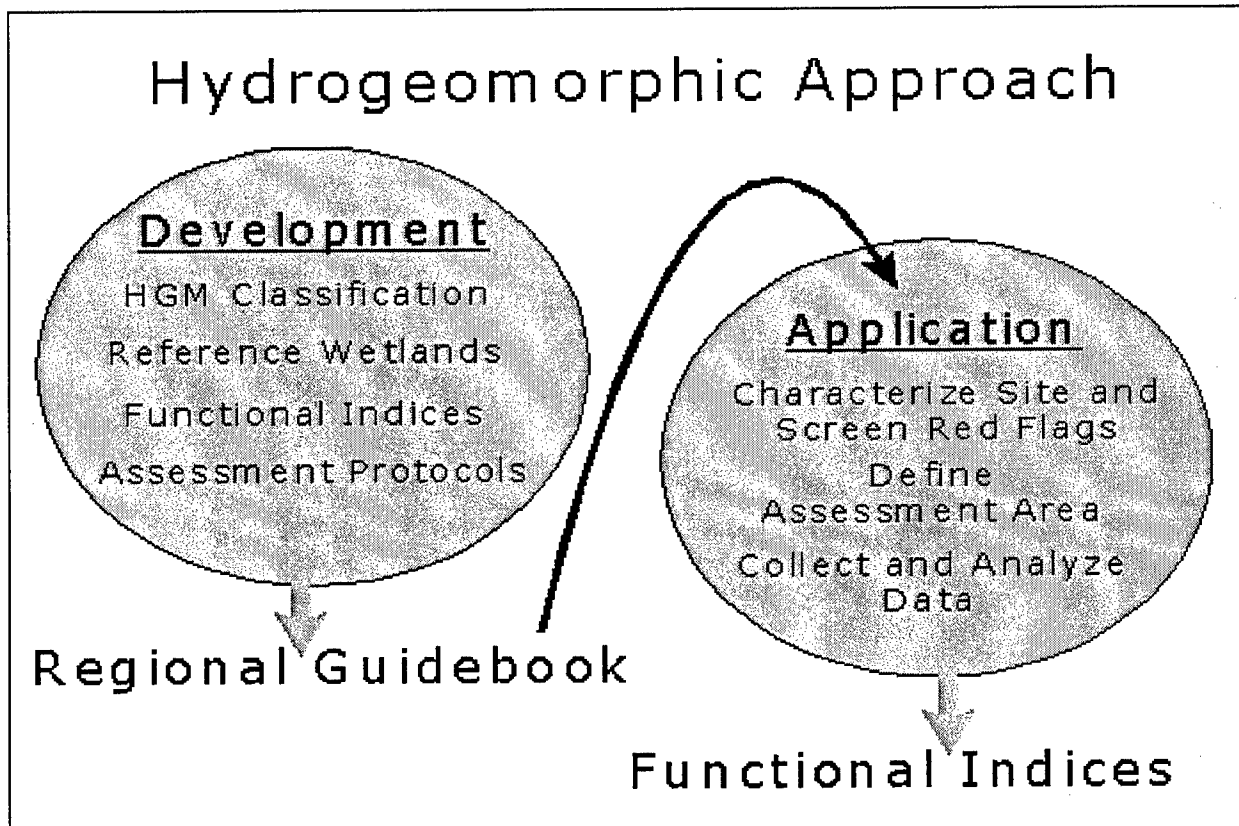


Figure 1. Development and Application Phases of the HGM Approach (from Ainslie et al. 1999)

- Define assessment objectives.
- Characterize the project site.
- Screen for red flags.
- Define the Wetland Assessment Area.
- Collect field data.
- Analyze field data.

The second step involves applying the results of the assessment at various decision-making points in the planning or permit review sequence, such as alternatives analysis, impact minimization, assessment of unavoidable impacts, determination of compensatory mitigation, design and monitoring of mitigation, comparison of wetland management alternatives or results, determination of restoration potential, or identification of acquisition or mitigation sites.

Each of the components of the HGM Approach that are developed and integrated into the Regional Guidebook is discussed briefly in the following paragraphs. More extensive treatment of these components can be found in Brinson (1993a,b; 1995, 1996), Brinson et al. (1995, 1996, 1998), Hauer and Smith (1998), and Smith et al. (1995).

## Hydrogeomorphic Classification

Wetland ecosystems share a number of common attributes including hydrophytic vegetation, hydric soils, and relatively long periods of inundation or saturation by water. In spite of these common attributes, wetlands occur in a variety of climatic, geologic, and physiographic settings and exhibit a wide range of physical, chemical, and biological characteristics and processes (Cowardin et al. 1979; Mitch and Gosselink 1993; Semeniuk 1987). The variability of wetlands makes it challenging to develop assessment methods that are both accurate (i.e., sensitive to significant changes in function) and practical (i.e., can be completed in the relatively short time frame normally available for conducting assessments). "Generic" wetland assessment methods have been developed to assess multiple wetland types throughout the United States. In general these methods can be applied quickly, but lack the resolution necessary to detect significant changes in function. One way to achieve an appropriate level of resolution within a limited time frame is to employ a wetland classification system structured to support functional assessment objectives (Smith et al. 1995).

The HGM classification was developed specifically to accomplish this task (Brinson 1993a). It identifies groups of wetlands that function similarly using three criteria that fundamentally influence how wetlands function: geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the position of the wetland in the landscape. Water source refers to the primary origin of the water that sustains wetland characteristics, such as precipitation, floodwater, or groundwater. Hydrodynamics refers to the level of energy with which water moves through the wetland, and the direction of water movement.

Based on these three criteria, any number of functional wetland groups can be identified at different spatial or temporal scales. For example, at a continental scale, Brinson (1993a,b) identified five hydrogeomorphic wetland classes. These were later expanded to the seven classes described in Table 1 (Smith et al. 1995).

Generally, the level of variability encompassed by wetlands at the continental scale of hydrogeomorphic classification is too great to allow development of assessment indices that can be applied rapidly and still retain the level of sensitivity necessary to detect changes in function at a level of resolution appropriate to the 404 permit review. In order to reduce both inter- and intraregional variability, the three classification criteria must be applied at a smaller, regional geographic scale, thus creating regional wetland subclasses. In many parts of the country, existing wetland classifications can serve as a starting point for identifying these regional subclasses (e.g., Golet and Larson 1974; Stewart and Kantrud 1971; Wharton et al. 1982). Regional subclasses, like the continental scale wetland classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. Examples of potential regional subclasses are shown in Table 2. In addition, certain ecosystem or landscape characteristics may be useful for distinguishing regional subclasses. For example, depression subclasses might be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow

<b>Table 1</b> <b>Hydrogeomorphic Wetland Classes</b>	
<b>HGM Wetland Class</b>	<b>Definition</b>
Depression	Depressional wetlands occur in topographic depressions (i.e., closed elevation contours) that allow the accumulation of surface water. Depressional wetlands may have any combination of inlets and outlets, or lack them completely. Potential water sources are precipitation, overland flow, streams, or groundwater flow from adjacent uplands. The predominant direction of flow is from the higher elevations toward the center of the depression. The predominant hydrodynamics are vertical fluctuations that may occur over a range of time, from a few days to many months. Depressional wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater. Prairie potholes, playa lakes, and cypress domes are common examples of depressional wetlands.
Tidal Fringe	Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal current diminishes and riverflow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. Because tidal fringe wetlands are frequently flooded and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally accumulates in higher elevation marsh areas where flooding is less frequent and the wetlands are isolated from shoreline wave erosion by intervening areas of low marsh or dunes. <i>Spartina alterniflora</i> salt marshes are a common example of tidal fringe wetlands.
Lacustrine Fringe	Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional. Lacustrine wetlands lose water by evapotranspiration and by flow returning to the lake after flooding. Organic matter may accumulate in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are an example of lacustrine fringe wetlands.
Slope	Slope wetlands are found in association with the discharge of groundwater to the land surface or on sites with saturated overland flow with no channel formation. They normally occur on slightly to steeply sloping land. The predominant source of water is groundwater or interflow discharging at the land surface. Precipitation is often a secondary contributing source of water. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturated subsurface flows, surface flows, and by evapotranspiration. They may develop channels, but the channels serve only to convey water away from the slope wetland. Slope wetlands are distinguished from depression wetlands by the lack of a closed topographic depression and the predominance of the groundwater/interflow water source. Fens are a common example of slope wetlands.
Mineral Soil Flats	Mineral soil flats are most common on interfluvies, extensive relic lake bottoms, or large alluvial terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, which distinguishes them from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. Mineral soil flats lose water by evapotranspiration, overland flow, and seepage to underlying groundwater. They are distinguished from flat non-wetland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and low hydraulic gradients. Pine flatwoods with hydric soils are an example of mineral soil flat wetlands.

(Continued)

<b>Table 1 (Concluded)</b>	
<b>HGM Wetland Class</b>	<b>Definition</b>
Organic Soil Flats	Organic soil flats, or extensive peatlands, differ from mineral soil flats in part because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluvies, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by overland flow and seepage to underlying groundwater. They occur in relatively humid climates. Raised bogs share many of these characteristics but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are examples of organic soil flat wetlands.
Riverine	Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank or backwater flow from the channel. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. In headwaters, riverine wetlands often intergrade with slope, depression, poorly drained flat wetlands, or uplands as the channel (bed) and bank disappear. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration. Bottomland hardwood forests on floodplains are examples of riverine wetlands.

<b>Table 2 Potential Regional Wetland Subclasses in Relation to Classification Criteria</b>				
<b>Classification Criteria</b>			<b>Potential Regional Wetland Subclasses</b>	
<b>Geomorphic Setting</b>	<b>Dominant Water Source</b>	<b>Dominant Hydrodynamics</b>	<b>Eastern USA</b>	<b>Western USA/Alaska</b>
Depression	Groundwater or interflow	Vertical	Prairie pothole marshes, Carolina bays	California vernal pools
Fringe (tidal)	Ocean	Bidirectional, horizontal	Chesapeake Bay and Gulf of Mexico tidal marshes	San Francisco Bay marshes
Fringe (lacustrine)	Lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes
Slope	Groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Flat (mineral soil)	Precipitation	Vertical	Wet pine flatwoods	Large playas
Flat (organic soil)	Precipitation	Vertical	Peat bogs; portions of Everglades	Peatlands over permafrost
Riverine	Overbank flow from channels	Unidirectional, horizontal	Bottomland hardwood forests	Riparian wetlands
Note: Adapted from Smith et al. 1995, Rheinhardt et al. 1997.				

of surface water in or out of the depression through defined channels). Tidal fringe subclasses might be based on salinity gradients (Shafer and Yozzo 1998). Slope subclasses might be based on the degree of slope or landscape position. Riverine subclasses might be based on position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Regional Guidebooks



include a thorough characterization of the regional wetland subclass in terms of geomorphic setting, water sources, hydrodynamics, vegetation, soil, and other features that were taken into consideration during the classification process.

## Reference Wetlands

Reference wetlands are the wetland sites selected to represent the range of variability that occurs in a regional wetland subclass as a result of natural processes and disturbance (e.g., succession, channel migration, fire, erosion, and sedimentation) as well as anthropogenic alteration (e.g., grazing, timber harvest, clearing). The reference domain is the geographic area occupied by the reference wetlands (Smith et al. 1995, Smith 2001). Ideally, the geographic extent of the reference domain will mirror the geographic area encompassed by the regional wetland subclass; however, this is not always possible due to time and resource constraints.

Reference wetlands serve several purposes. First, they establish a basis for defining what constitutes a characteristic and sustainable level of function across the suite of functions selected for a regional wetland subclass. Second, reference wetlands establish the range and variability of conditions exhibited by assessment variables, and provide the data necessary for calibrating assessment variables and models. Finally, they provide a concrete physical representation of wetland ecosystems that can be observed and remeasured as needed.

Reference standard wetlands are the subset of reference wetlands that perform the suite of functions selected for the regional subclass at a level that is characteristic of the least altered wetland sites in the least altered landscapes. Table 3 outlines the terms used by the HGM Approach in the context of reference wetlands.

<b>Table 3</b>	
<b>Reference Wetland Terms and Definitions</b>	
<b>Term</b>	<b>Definition</b>
Reference Domain	The geographic area from which reference wetlands representing the regional wetland subclass are selected.
Reference Wetlands	A group of wetlands that encompass the known range of variability in the regional wetland subclass resulting from natural processes and human alteration.
Reference Standard Wetlands	The subset of reference wetlands that perform a representative suite of functions at a level that is both sustainable and characteristic of the least human altered wetland sites in the least human altered landscapes. By definition, the functional capacity index for all functions in a reference standard wetland is 1.0.
Reference Standard Wetland Variable Condition	The range of conditions exhibited by assessment variables in reference standard wetlands. By definition, reference standard conditions receive a variable subindex score of 1.0.

## Assessment Models and Functional Indices

In the HGM Approach, an assessment model is a simple representation of a function performed by a wetland ecosystem. The assessment model defines the

relationship between the characteristics and processes of the wetland ecosystem and the surrounding landscape that influence the functional capacity of a wetland ecosystem. Characteristics and processes are represented in the assessment model by assessment variables. Functional capacity is the ability of a wetland to perform a specific function relative to the ability of reference standard wetlands to perform the same function. Application of assessment models results in a Functional Capacity Index (FCI) ranging from 0.0 to 1.0. Wetlands with an FCI of 1.0 perform the assessed function at a level that is characteristic of reference standard wetlands. A lower FCI indicates that the wetland is performing a function at a level below the level that is characteristic of reference standard wetlands.

For example, the following equation shows an assessment model that could be used to assess the capacity of a wetland to detain floodwater.

$$FCI = V_{FREQ} \times \left[ \frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right]$$

The assessment model has five assessment variables: frequency of flooding ( $V_{FREQ}$ ), which represents the frequency at which a wetland is inundated by overbank flooding, and the assessment variables of log density ( $V_{LOG}$ ), ground vegetation cover ( $V_{GVC}$ ), shrub and sapling density ( $V_{SSD}$ ), and tree stem density ( $V_{TDEN}$ ) that together represent resistance to flow of floodwater through the wetland.

Assessment variables occur in a variety of states or conditions. The state or condition of an assessment variable is indicated by the value of the metric used to assess a variable, and the metric used is normally one commonly used in ecological studies. For example, tree basal area ( $m^2/ha$ ) is the metric used to assess tree biomass in a wetland, with larger numbers usually indicating greater stand maturity and increasing functionality for several different wetland functions where tree biomass is an important consideration.

Based on the metric value, an assessment variable is assigned a variable subindex. When the metric value of an assessment variable is within the range of conditions exhibited by reference standard wetlands, a variable subindex of 1.0 is assigned. As the metric value deflects, in either direction, from the reference standard condition, the variable subindex decreases based on a defined relationship between metric values and functional capacity. Thus, as the metric value deviates from the conditions documented in reference standard wetlands, it receives a progressively lower subindex reflecting the decreased functional capacity of the wetland. Figure 2 illustrates the relationship between metric values of tree density ( $V_{TDEN}$ ) and the variable subindex for an example wetland subclass. As shown in the graph, tree densities of 200 to 400 stems/ha represent reference standard conditions, based on field studies, and a variable subindex of 1.0 is assigned for assessment models where tree density is a component. Where tree densities are higher or lower than those found in reference standard conditions, a lesser variable subindex value is assigned.

## Assessment Protocol

All of these steps described in the preceding sections concern development of the assessment tools and the rationale used to produce this Regional Guidebook. Although users of the guidebook should be familiar with this process, their primary concern will be the protocol for application of the assessment procedures. The assessment protocol is a defined set of tasks, along with specific instructions, that allows resource professionals to assess the functions of a particular wetland area using the assessment models and functional indices in the Regional Guidebook. The first task includes characterizing the wetland ecosystem and the surrounding landscape, describing the proposed project and its potential impacts, and identifying the wetland areas to be assessed. The second task is collecting the field data for assessment variables. The final task is an analysis that involves calculation of functional indices. These steps are described in detail in Chapter 6, and the required data forms, spreadsheets, and supporting digital spatial data are provided in Appendices A through D.

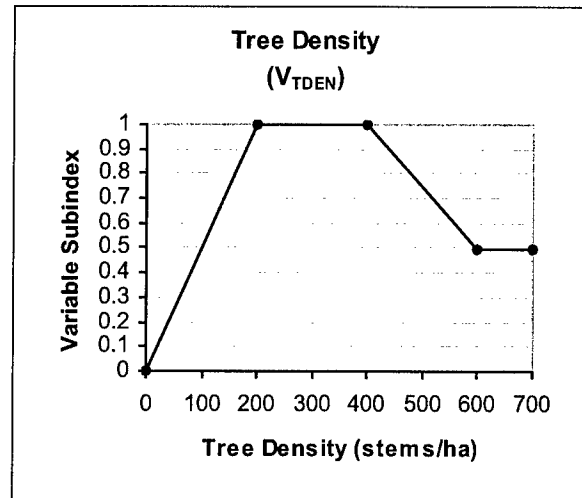


Figure 2. Example subindex graph for the Tree Density ( $V_{TDEN}$ ) assessment variable for a particular wetland subclass

### 3 Characterization of Wetland Subclasses in the Delta Region of Arkansas

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#### Reference Domain

The reference domain for this guidebook (i.e., the area from which reference data were collected and to which the guidebook can be applied) is the Delta Region of Arkansas, which is that portion of the alluvial valley of the Mississippi River that lies within Arkansas, bounded on the west by the Ozark and Ouachita Mountains, the Arkansas River Valley, and the West Gulf Coastal Plain, and on the east by the Mississippi River levee (Figure 3). The area between the Mississippi River and the main-line levee system that controls Mississippi River flooding (commonly called the batture) is not included in the reference domain. Crowley's Ridge, a narrow, elongate remnant coastal plain feature of Tertiary age rising as much as 75 m above the surrounding alluvial terrain in the northeastern part of the Arkansas Delta, also is not included in the reference domain. All references to the Delta Region of Arkansas in this report are intended to reflect the limits on the reference domain as described, and do not include the Mississippi River batture or Crowley's Ridge.

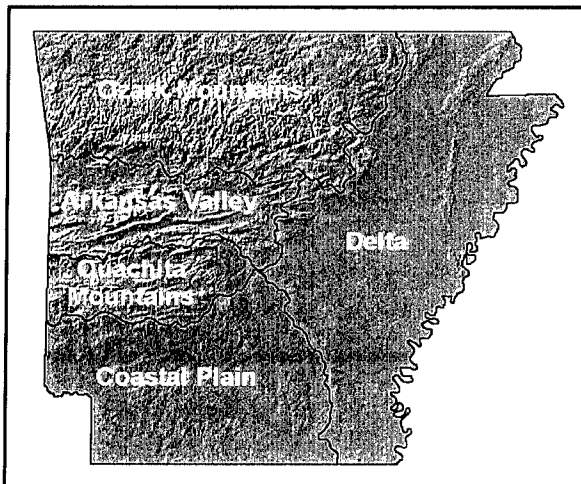


Figure 3. Wetland planning regions of Arkansas

All of the wetlands within the reference domain are on landforms created by the action of the Mississippi River or its tributaries. In order to classify and assess wetlands in the region, it is important to understand the geology and geomorphology of both the Lower Mississippi Valley as a whole and the Delta Region of Arkansas, as well as the effects of human alterations to that landscape. The following sections review major concepts that have bearing on the

classification and functions of wetlands in the modern landscape of the Delta Region of Arkansas. Descriptions of the wetland classes and subclasses that occur in the Delta and guidelines for recognizing them in the field are presented as the final section of this chapter.

## **Physiography and Climate**

The Delta Region of Arkansas is part of the Mississippi River Alluvial Valley, which is defined by Saucier (1994) as that portion of the Lower Mississippi Valley that is characterized by landforms and deposits that are primarily of Holocene and Wisconsin age. Certain pre-Wisconsin Pleistocene features of fluvial origin also are included. This definition excludes Crowley's Ridge, but includes the Grand Prairie area in Arkansas. Surface topography within the alluvial valley is defined by the characteristics of a deep alluvial fill that overlies Coastal Plain geologic formations and deeper Paleozoic and older rocks. Except for the mountains in Arkansas, the Lower Mississippi Alluvial Valley is bounded on the east and west by exposures of the Coastal Plain sediments.

Climate within the Delta Region of Arkansas is humid subtropical, with temperate winters and long hot summers. Prevailing southerly winds carry moisture from the Gulf Coast, creating high humidity levels and a high incidence of thunderstorms. Tornadoes and ice storms occur commonly in the area. Daily mean temperatures at Little Rock, on the west-central edge of the Delta Region, range from a low in January of 36.9 °F (2.7 °C) to a high of 81.5 °F (27.5 °C) in July, with an overall annual average of 61.8 °F (16.5 °C). Daily average maximum temperatures are 92.4 °F (33.5 °C) in July and 49.0 °F (9.4 °C) in January. Freezing temperatures reach the entire area for short periods in most years (Brown et al. 1971; Southern Regional Climate Center 2002).

Long-term average total precipitation does not vary greatly within the Delta Region of Arkansas. At Little Rock, the annual average is 50.86 in. (129.18 cm), with the most precipitation falling in April (5.49 in. or 13.94 cm), and the least in August (3.26 in. or 8.28 cm) (Southern Regional Climate Center 2002). Snow or sleet falls in the area in most years, but does not persist. The distribution of precipitation is such that excess moisture is present in the winter and spring months, and frequent soil moisture deficits occur in the months of June through September.

## **Drainage System and Hydrology**

The dominant drainage feature of the Mississippi Alluvial Valley is the Mississippi River. The drainage area of the Mississippi River basin is approximately 3,227,000 sq km, which is about 41 percent of the land area of the continental United States (USACE 1973). Major floods on the lower Mississippi River usually originate in the Ohio River basin, and can crest in any month from January to May. High flows that originate in the upper Mississippi River system generally occur in late spring and early summer (Tuttle and Pinner 1982).

Average flow of the Mississippi River at Vicksburg, MS (which includes the flow from the Arkansas River and its tributaries), is 16,225 cu m/sec (573,000 cfs), and 225 million metric tons (250 million tons) of sediment are transported past that point annually (Bolton and Metzger 1998). Discharges during floods often have been 3 to 4 times the average flow. The 1927 flood peak discharge at Vicksburg was approximately 64,500 cu m/sec (2,278,000 cfs) (Tuttle and Pinner 1982). Seventeen major floods have occurred on the Lower Mississippi River since 1879. This is an average of one major flood every 7 years, but the actual interval between major events has ranged from 1 to 23 years (U.S. Army Engineer Division, Mississippi Valley, 1998).

Prior to construction of modern levees, major Mississippi River floods would have inundated about half of the Delta Region of Arkansas (Moore 1972). Although modern mainstem levees generally prevent overbank Mississippi River flooding, they do not completely eliminate the influence of the river on hydrology of the region. High stages on the Mississippi River cause impeded drainage of tributary streams, which results in backwater flooding. Under certain conditions, backwater flooding may be aggravated by levees that block return flows as mainstem water levels fall. Major backwater areas in the Arkansas Delta are in the St. Francis Basin and along the lower Arkansas and White Rivers.

The second largest stream in the Delta Region is the Arkansas River, which traverses the Delta in a southeasterly direction from Little Rock to its junction with the Mississippi River about 30 km above Arkansas City. There are about 225 kilometers of Arkansas River channel in the Delta, but the vast majority of its 416,000-sq-km drainage basin is outside of Arkansas in Oklahoma, Kansas, Texas, Colorado, and New Mexico (Moore 1972).

Neither the Mississippi River nor the Arkansas receive much direct overland runoff as they traverse the Delta Region because of the effects of both natural and man-made levees. Rather, most of the area drains to those rivers through tributaries that gather runoff within defined basins. The Arkansas Multi-Agency Wetland Planning Team has grouped the Delta drainage basins into Wetland Planning Areas (WPA), which are briefly described in the following paragraphs and illustrated in Figure 4.

Streams arising south and west of the Arkansas River occupy the Bayou Bartholomew and Boeuf River/Bayou Macon basins. These areas drain generally southward, eventually discharging to the Mississippi in Louisiana via the Ouachita and Red River systems.

The Bayou Meto basin drains most of the lowlands immediately north and east of the Arkansas River, as well as parts of the Grand Prairie. The principal internal streams are Bayou Meto and Bayou Two Prairie. It is the only major basin within the Delta that discharges directly to the Arkansas River.

Most of the Delta north of the Arkansas River drains to the Mississippi via the White River. The White River arises in the Ozarks and enters the Delta near Newport, then flows generally southward to join the Mississippi in the same vicinity as the confluence of the Arkansas River. The lower White River receives

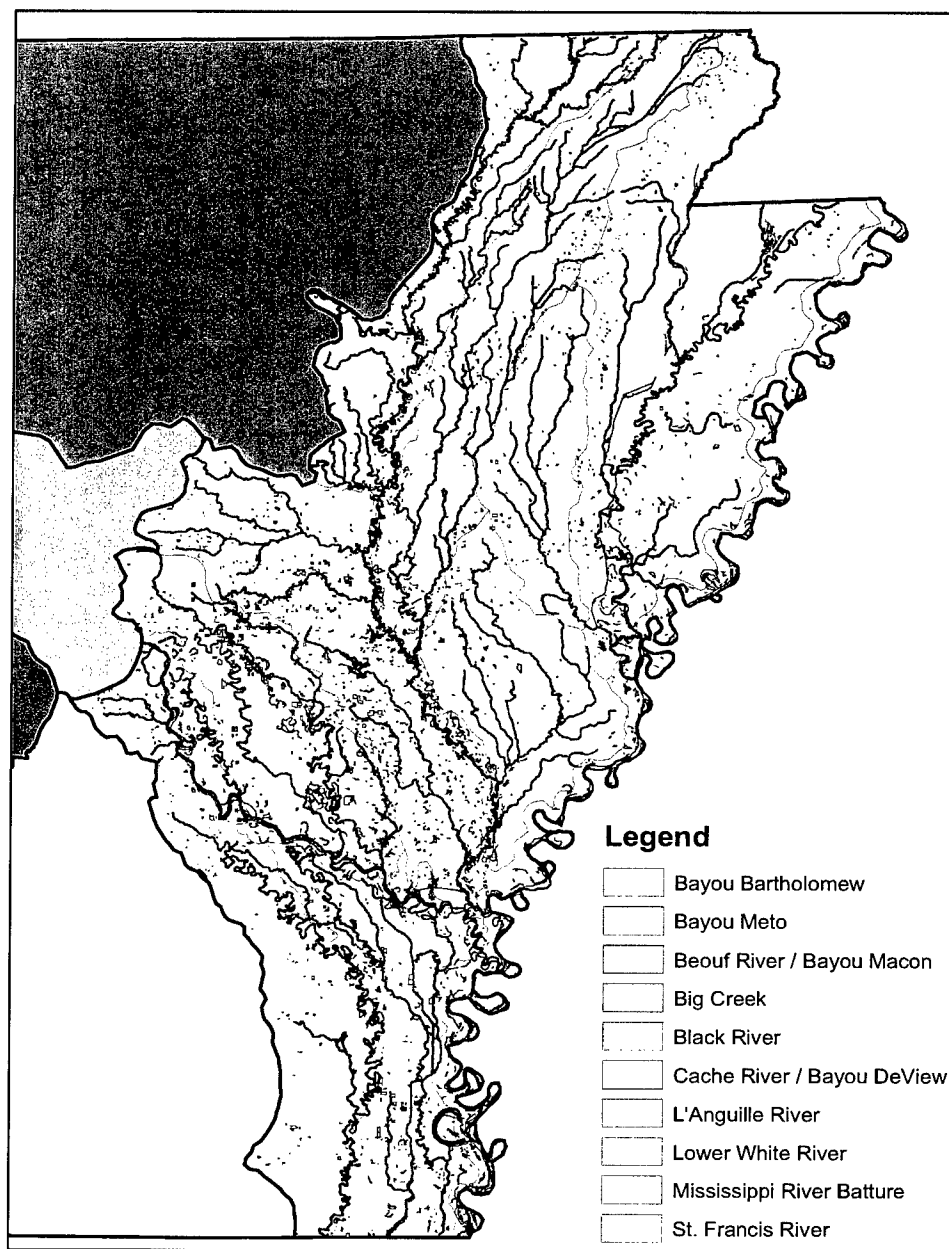


Figure 4. Wetland Planning Areas of the Delta Region of Arkansas

drainage from a variety of small streams on its western flank, including most of the drainage from the Grand Prairie. In addition, there are three other basins (or WPAs) within the Delta that discharge to the White River, and from there to the Mississippi: the Black River, which lies along the flank of the Ozarks and includes the White River above its confluence with the Little Red River; the Cache River/Bayou DeView basin, which lies between the Black River WPA and Crowley's Ridge; and Big Creek, which drains the area between the lower White River and the Mississippi.

The St. Francis River system in northeastern Arkansas arises in southeastern Missouri and empties into the Mississippi north of Helena. Most of its internal tributaries have been straightened and deepened and incorporated into a massive drainage system. Near the point where the St. Francis discharges into the Mississippi River, it receives the flow of the L'Anguille River WPA, which is a much less altered basin draining the area on the eastern flank of Crowley's Ridge.

Groundwater also is a significant component of the hydrology of the Delta Region of Arkansas. The alluvial aquifer within the Mississippi Alluvial Valley occupies coarse-grained deposits that originated as glacial outwash and from more recent alluvial activity. Generally, the surface of the alluvial aquifer is within 10 m of the land surface, and it is approximately 38 m thick. It is essentially continuous throughout the Mississippi Alluvial Valley. Where the topstratum is made up of coarse sediments or thinly veneered with fine sediments, the alluvial aquifer is recharged by surface waters. Discharge is primarily to stream channels, which contributes to stream baseflow during low-flow periods (Saucier 1994; Terry et al. 1979).

All of the major elements of the drainage system and hydrology of the Delta Region of Arkansas have been modified to varying degrees in historic times. At the time of European settlement, much of the Delta Region of Arkansas was subject to prolonged, extensive ponding following the winter wet season in virtually all years, localized short-term ponding following rains at any time of year, and extensive inundation within tributary floodbasins due to rainfall in headwater areas in most years. During major flood events, large-scale backwater flooding influenced tributary systems, and complete inundation of much of the basin occurred when Mississippi River stages were high enough to cause overbank flows. The engineering projects and agricultural activities, which have incrementally altered and continue to alter these various sources of wetland hydrology, are described in the Alterations to Environmental Conditions section.

## **Geology and Geomorphology**

### **Development of the Mississippi Alluvial Valley**

The first comprehensive discussion of the geology and geomorphology of the Mississippi Alluvial Valley was presented by Fisk (1944). The only major reassessments since that work have been an overview by Autin et al. (1991), and a major synthesis by Saucier (1994). Unless otherwise attributed, the following discussion is derived primarily from the latter source.

The Mississippi Alluvial Valley had its origins in the continental rifting, warping, and uplifting that shaped the Mississippi Embayment, a massive syncline where Paleozoic rocks downwarp as much as 3,000 m. Areas of narrowing and changes in the orientation of the Lower Mississippi Valley reflect areas of uplift in west-central and southern Mississippi, northeastern Louisiana, and southeastern Arkansas. Faulting has occurred at various locations, but the effects are not particularly evident in most instances. However, faulting and uplift have occurred in recent times (Holocene) in the northern portion of the Lower



Mississippi Valley in the area known as the New Madrid Earthquake Zone. Some of the more dramatic effects of this activity can be seen in the Reelfoot Lake area of western Tennessee, but some surface features in northeastern Arkansas also can be traced to tectonic activity, particularly the series of earthquakes that occurred in 1811–1812. Extensive “sand blows,” streambank caving, and stream channel realignments have been attributed to those events, as well as a probable deepening of the swamps in the Big Lake region of the St. Francis Basin (Saucier 1994).

The modern valley is, for the most part, bounded by Tertiary and Mesozoic sediments of the Gulf Coastal Plain (Autin et al. 1991), although the major part of the western valley wall in Arkansas is made up of older (Paleozoic) rocks, as is Crowley’s Ridge (Saucier 1994). Crowley’s Ridge, portions of the uplands forming the western valley wall, and many of the older (Pleistocene) fluvial surfaces within the Delta are blanketed with multiple layers of wind-blown fine silts (loess) that originated in the glacial outwash carried down the Mississippi Valley during waning Pleistocene glacial cycles.

Although the Lower Mississippi Valley developed as a result of the downwarping of Paleozoic rocks and confinement by uplifted surfaces, the characteristics of the existing landscape were shaped largely by erosion and deposition processes. By the end of the Tertiary, the downwarped surface had been largely filled by sediments transported from the north and upland flanks to the east and west. The ancestral Mississippi River was established in a valley smaller than the present, the source area (drainage area) was smaller than it is now, and the river had lower discharge. Pleistocene glaciation enlarged the drainage area of the river by diverting formerly north-flowing rivers into the Mississippi system. Over an estimated 2.8 million years, periods of waxing and waning glaciation and associated changes in flows, sediment loads, and base level gradually produced a wider valley filled with thick alluvium, with the Mississippi and Ohio Rivers flowing on opposite sides of Crowley’s Ridge and converging somewhere south of present-day Helena, Arkansas. This general configuration was maintained until late in the Wisconsin stage, when the Mississippi shifted east of the Ridge and the Ohio became confluent farther north.

Two fundamentally different fluvial regimes have shaped the principal landscape features of the Arkansas Delta in approximately equal proportions. Most of the northern half of the delta is made up of landforms that resulted from multiple glacial outwash events during Wisconsin glacial cycles. These areas usually exhibit surface features characteristics of braided-stream depositional environments, such as relict braid bars and gathering channels, although those features may be obscured by later alluvial or wind-blown deposits. Land surfaces in the delta established at various other times during the Pleistocene and Holocene eras are composed primarily of meandering-river depositional features (Figure 5).

Remnants of pre-Wisconsin Arkansas and Mississippi River meander belts remain in the delta as high terraces, primarily along the southwestern valley wall and as the extensive terrace peninsula known as the Grand Prairie. There are also much later, lower elevation Wisconsin-age alluvial terraces along the southern

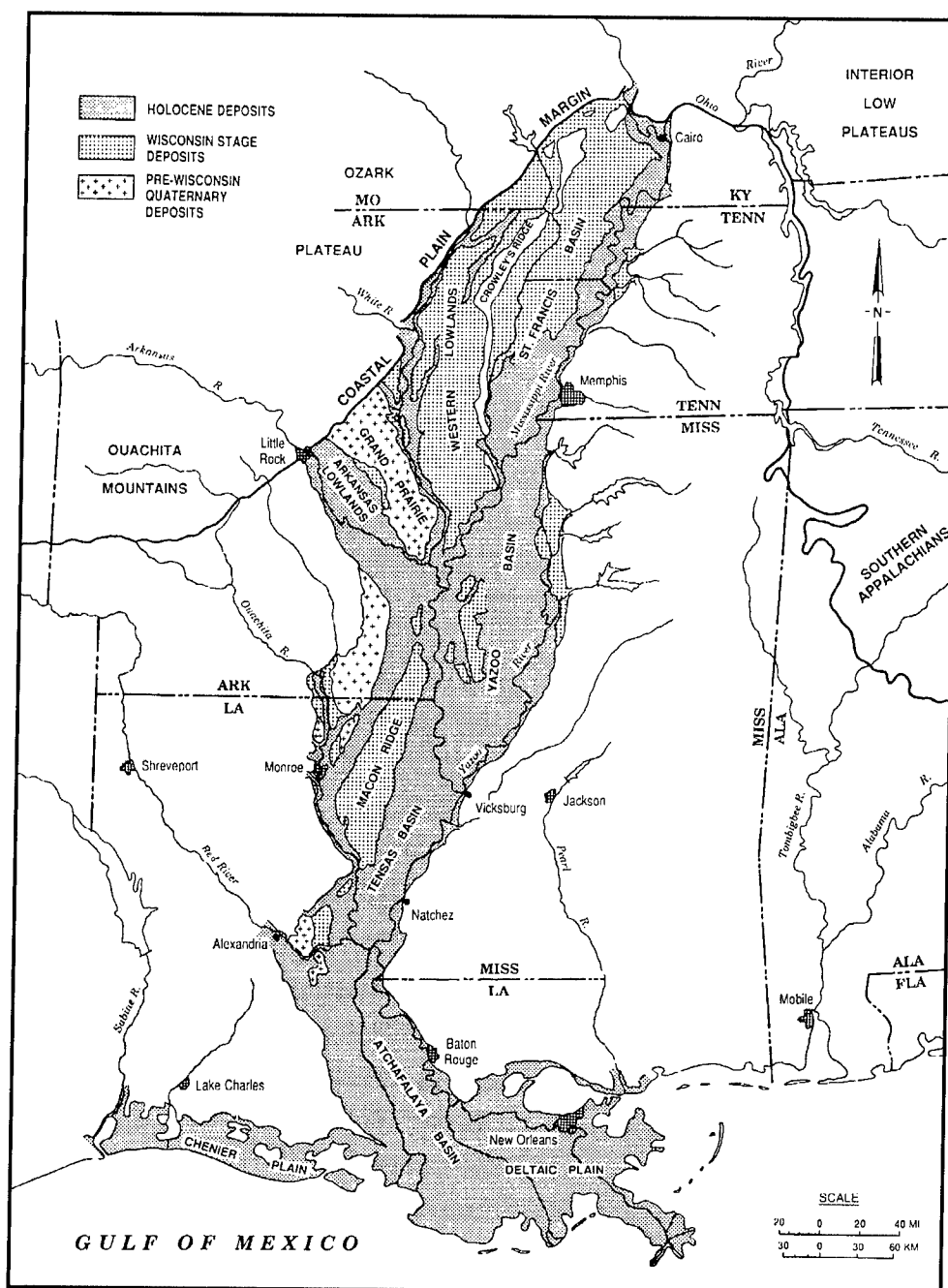


Figure 5. Distribution of the principal Quaternary deposits in the Lower Mississippi River Alluvial Valley (adapted from Saucier 1994)

margin of the Grand Prairie and adjacent to the Cache River. All of the alluvial terraces are characterized by features such as relict meandering channel segments, rather than the braided channels of the outwash or “valley train terraces,” although the Wisconsin-age alluvial terraces tend to have larger meander features and thicker alluvial deposits because they formed during periods of much higher flows. A third major set of meandering-stream floodplain features was created after glacial outwash deposition ceased within the Lower Mississippi Alluvial Valley at the beginning of the Holocene epoch about 10,000 years ago. Sea level

variation continued to influence depositional processes in the southernmost parts of the valley, but in the central and northern portions of the valley all Holocene alluvial surfaces have been the result primarily of meandering stream processes. The Mississippi and Arkansas Rivers and various smaller streams have reworked portions of the glacially deposited material within broad meander belts, and the larger streams have relocated and established new meander belts at various times.

Within its meander belts, the Mississippi River has removed the pre-Holocene glacial outwash to an average depth of about 30 m (the average depth of the river channel), and replaced it with a complex of depositional features that includes abandoned stream channels, abandoned stream courses, point bar deposits, and natural levees. The current meander belt extends into the Arkansas Delta about 5 to 30 km from the river channel, and it has been occupied and carrying the full flow of the Mississippi River for about 2000 years. Smaller remnants of several older meander belts also remain in the Arkansas Delta, primarily east of Crowley's Ridge. Segments of various smaller streams, such as the L'Anguille River and Big Creek, now occupy portions of the former Mississippi River channels (abandoned courses) that remain within the older meander belts.

Multiple meander belts of the Arkansas River and intervening backswamps dominate the landscape of the Arkansas Delta south of the Grand Prairie. The backswamps and abandoned Arkansas River courses between Grand Prairie and the modern river now carry streams such as Plum Bayou and Bayou Meto. At various times in the past, the Arkansas flowed more directly southward into Louisiana, and remnants of those meander belts are currently occupied by Bayou Bartholomew and several smaller streams.

### **Geomorphic features of the Delta Region of Arkansas**

The combination of meandering-stream processes and glacial outwash events has resulted in distinctive landforms that have been mapped in considerable detail throughout the valley (Figure 6 and Appendix E). Within the Delta Region of Arkansas, these landforms are categorized as valley trains (comprising all outwash features), and a suite of features created by meandering streams (backswamps, point bars, abandoned channels, abandoned courses, and natural levees) that are distinctive within the Holocene meander belts, but muted on the older Pleistocene alluvial terrace surfaces (Figure 7) (Kolb et al. 1968; Saucier 1994). Each of these landforms is discussed in the following paragraphs.

**Valley trains.** Glacial outwash deposits have been episodically flushed into the Lower Mississippi Valley by the Mississippi and Ohio Rivers for more than a million years, and much of the valley fill underlying the Arkansas Delta is outwash. However, the outwash deposits that are present at the surface, generally termed *valley train* deposits, are the result of events during the various stages of Wisconsin glaciation, which spanned a period ranging from about 80,000 to 10,000 years ago. They dominate the Arkansas Delta north of the latitude of Memphis.

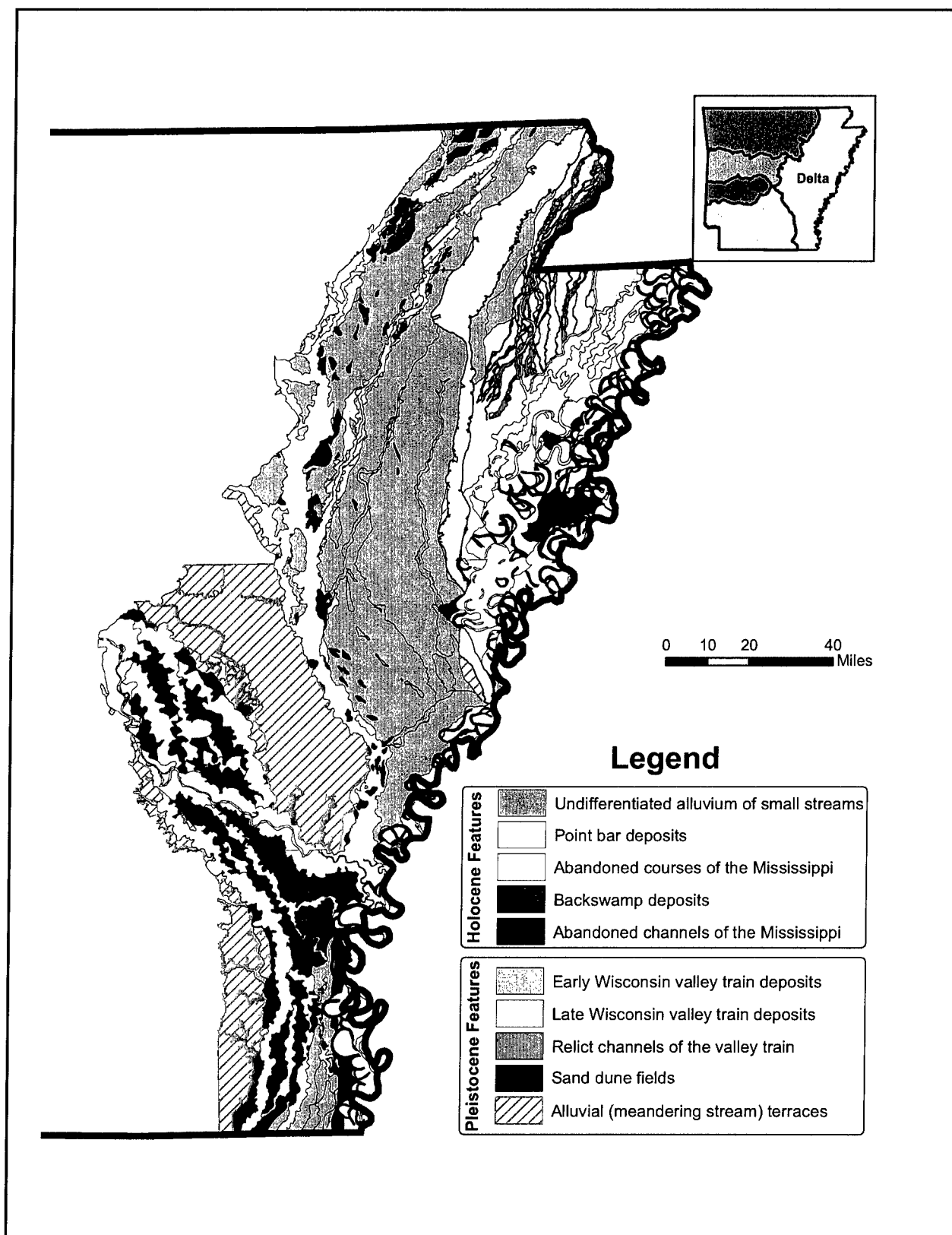


Figure 6. Distribution of the principal Quaternary deposits in the Delta Region of Arkansas (adapted from Saucier 1994). The unlabeled inclusion is Tertiary upland (Crowley's Ridge)

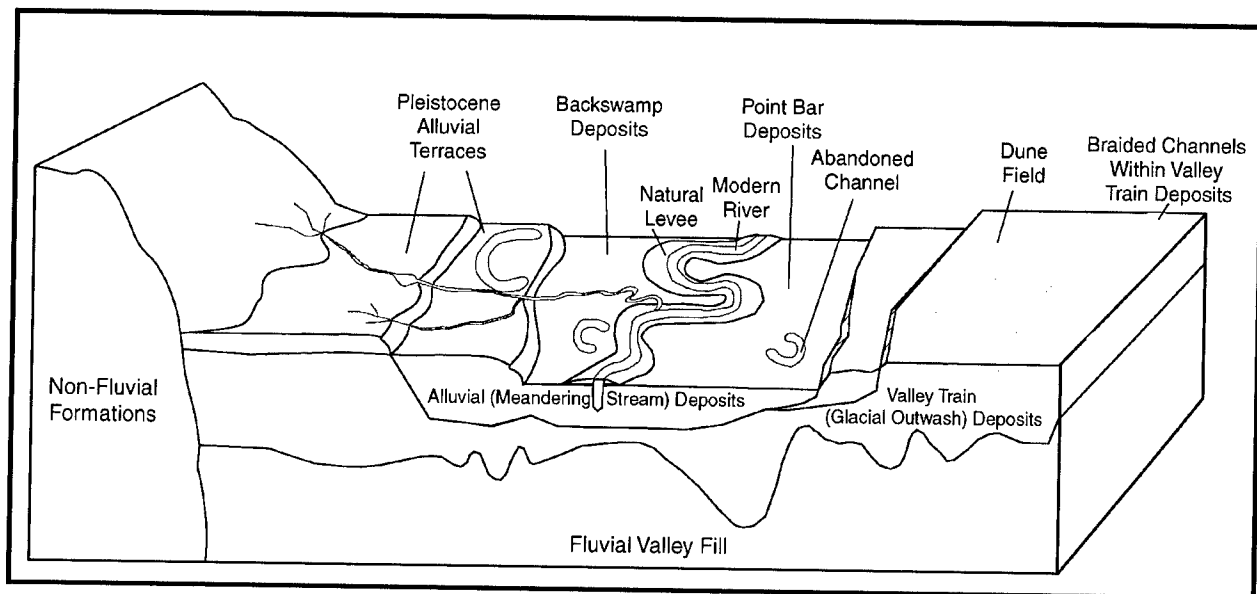


Figure 7. Principal geomorphic settings and features of the Delta Region of Arkansas

Valley trains consist of massive, coarse-grained deposits of relatively unsorted material deposited in a braided-stream environment. They are distinctive in that the ancient braided-stream channels are present and often recognizable at the surface. The topstratum of valley train deposits is a layer up to 3 m thick of predominantly fine-grained material that forms a continuous blanket across the relict braided channels and interfluvies. The topstratum may include materials laid down during waning stages of glacial outwash deposition, loess, and slackwater overbank deposits from later Mississippi River meander belts. Other than this relatively fine-grained surface veneer, the braided channel systems on valley trains, both near-surface and at depth, tend to be filled with coarse sands deposited as flows waned in a particular channel segment. This distinguishes valley train channels from abandoned channel segments in the Holocene meander belts of the Mississippi and Arkansas Rivers, which are typically filled with clays.

There are several distinct valley train terraces in Arkansas, the oldest and highest Early Wisconsin deposits standing 10 m or more above the modern floodplain surface, while the youngest Late Wisconsin deposits are approximately contiguous with the adjacent Holocene meander belts. The remnant outwash channels are clearly visible on aerial photos on the youngest surface, east of Crowley's Ridge, and have been mapped (Figure 8). On older valley train surfaces, outwash channels are obscured to varying degrees or have been captured by modern stream systems, but linear depressions and parallel drainage patterns remain as remnants of the Pleistocene surface channel systems.

Certain valley train surfaces are covered with extensive dunefields, made up of wind-blown sands deflated from Late Wisconsin outwash channels and deposited on the adjacent, older valley train terraces (Figures 6 and 7). These dunefields are unique to the Arkansas Delta Region of the Lower Mississippi Valley. Wind-blown silts (loess) from these and earlier outwash channels blanket much of the valley train surface in the Delta.

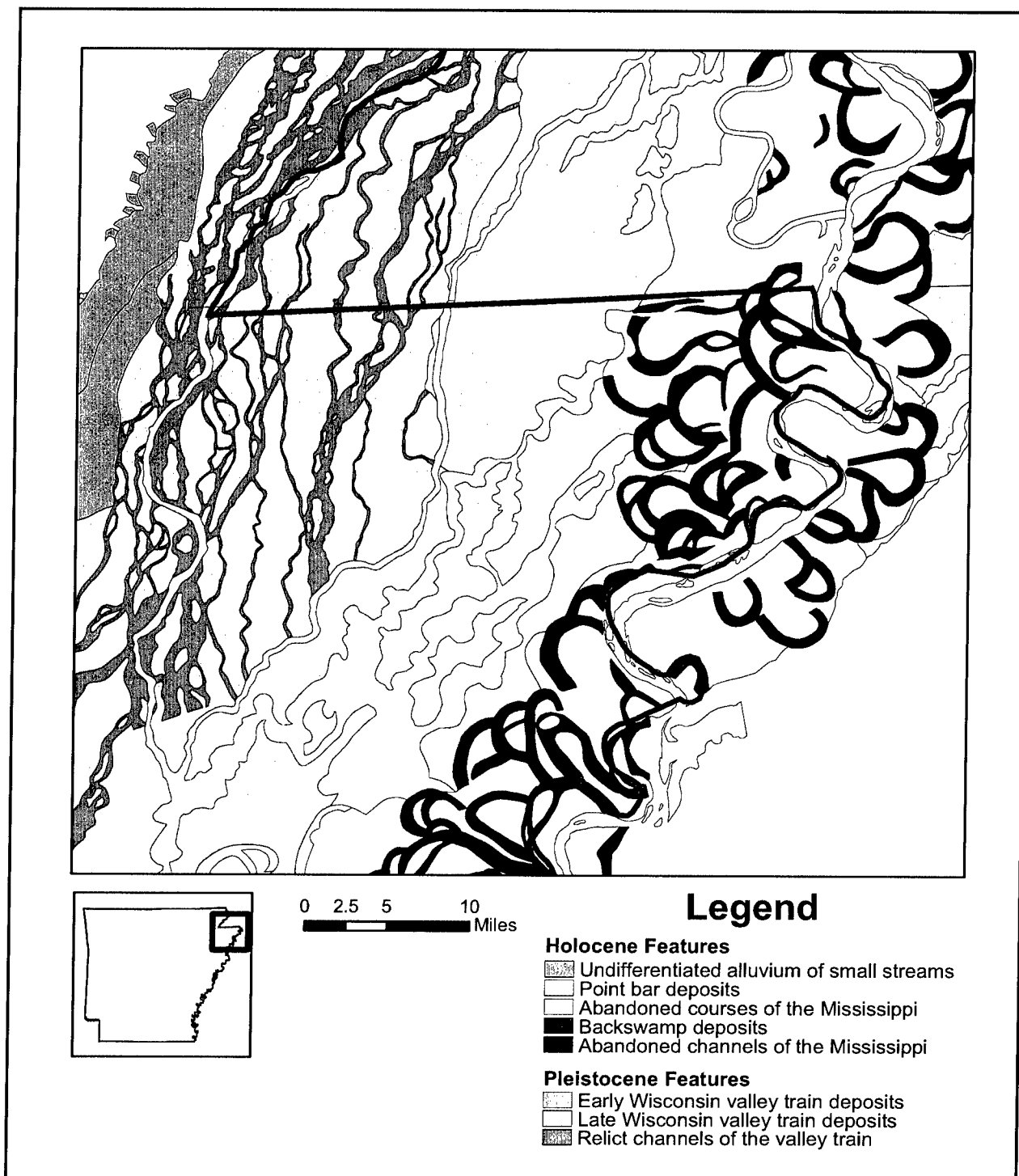


Figure 8. Geomorphic features of the Delta Region in Arkansas and parts of adjacent states, contrasting braided-stream Pleistocene outwash channels (left) and meandering-stream Holocene features (right) (adapted from Saucier 1994)

**Backswamps.** Backswamps are flat, poorly drained areas bounded by uplands and/or other features such as natural levees. In the Arkansas Delta, they are associated mostly with the multiple meander belts of the Mississippi River and especially the Arkansas River. Because sedimentation rates are highest along the active stream channel, meander belts tend to develop into an alluvial ridge, where elevations are higher than the adjacent floodplain. The result is that local drainage is directed away from the major stream channel, and the areas between meander belts become basins (backswamps) that collect runoff, pool floodwaters, and accumulate fine sediments. Backswamp environments in the Delta are underlain by coarse glacial outwash, but surface deposits are fine-grained sediments that were slowly deposited in slack-water conditions. Thus, under unmodified conditions, backswamps characteristically have substrates of massive clays, and are incompletely drained by small, sometimes anastomosing streams. They may include large areas that do not fully drain through channel systems but remain ponded well into the growing season. In much of the Mississippi Alluvial Valley, backswamp deposits are 12 m thick or more.

Note that sites mapped as valley train and backswamp have essentially the same sequence of deep, coarse glacial outwash overlain by fine-grained slack-water deposits. The basis for separating them as map units is the thickness of the fine-grained deposits – they are mapped as backswamp where the surface deposits are sufficiently thick to obscure the braided channel pattern on the valley train surface. On valley trains, surface deposits (other than those from historic erosion) are typically older and thinner and occupy better drained landscape positions than similar fine-grained deposits of backswamps.

Figures 7 and 9 illustrate typical locations of backswamps and other Holocene meander belt features relative to an active stream channel.

**Point bars.** Point bar deposits predominate within the Holocene meander belts in the Arkansas Delta. They generally consist of relatively coarse-grained materials (silts and sands) laid down on the inside (convex) bend of a meandering stream channel. The rate at which point bar deposition occurs and the height and width of individual deposits vary with sediment supply, flood stage, and other factors. The result is a characteristic pattern of low arcuate ridges separated by swales (“ridge and swale” or “meander scroll” topography). Point bar swales range from narrow and shallow to broad and deep, and usually are closed at each end to form depressions. The scale and depth of point bar swales depend on the depositional environment that formed the adjacent ridges and the degree of sedimentation within the swale since it formed.

**Abandoned channels.** These features are the result of cutoffs, where a stream abandons a channel segment either because flood flows have scoured out a point bar swale and created a new main channel (chute cutoff), or because migrating bendways intersect and channel flow moves through the neck (neck cutoff). Chute cutoffs tend to be relatively small and to fill rapidly with sediment. They do not usually form lakes, but may persist as large depressions. The typical sequence of events following a neck cutoff (which is much more common than a chute cutoff) is that the upper and lower ends of the abandoned channel segment

quickly fill with coarse sediments, creating an open oxbow lake (Figures 7 and 9). Usually, small connecting channels (batture channels) maintain a connection between the river and the lake, at least at high river stages, so river-borne fine-grained sediments gradually fill the abandoned channel segment. If this process is not interrupted, the lake eventually fills completely, the result being an arcuate swath of cohesive, impermeable clays within a better drained point bar deposit. Often, however, the river migrates away from the channel segment and the hydraulic connection is lost, or the connection is interrupted by later deposition of point bar or natural levee deposits. In either case, the filling process is dramatically slowed, and abandoned channel segments may persist as open lakes or depressions of various depths and dimensions.

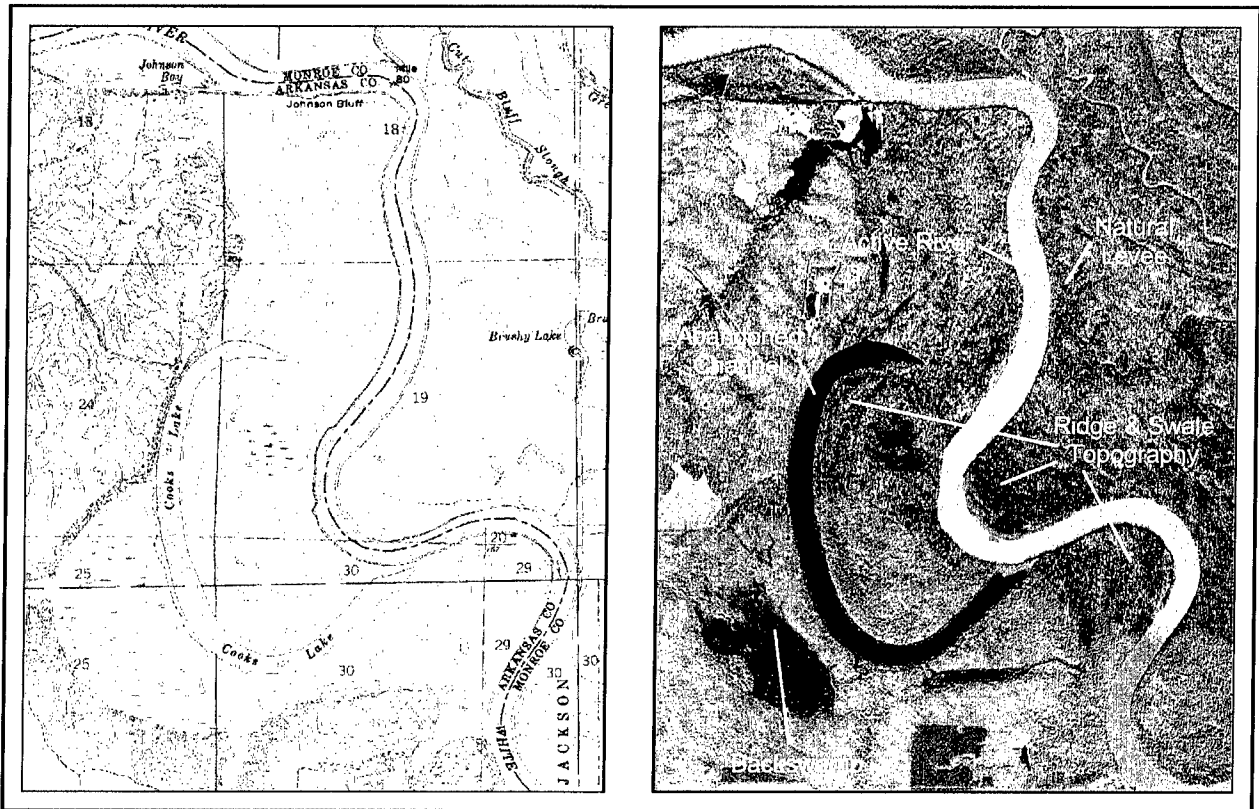


Figure 9. Topographic map and photomosaic showing typical geomorphic features of the Holocene meander belt of the lower White River. The higher terrain west of the river is part of the Grand Prairie Pleistocene alluvial terrace

**Abandoned courses.** An abandoned course is a stream channel segment left behind when a stream diverts flow to a new meander belt (Figure 8). Abandoned course segments can be hundreds of miles long, or only short segments may remain where the original course has been largely obliterated by subsequent stream activity. There are a variety of possible fates for abandoned courses. In some cases, they are captured by smaller streams, which meander within the former channel and develop their own point bars and other features. For example, within the Arkansas Delta, parts of the L'Anguille River and several smaller streams now flow within abandoned courses of the Mississippi River, and much of Bayou Macon and Bartholomew Bayou occupy abandoned courses of the



Arkansas River. Where the stream course is abandoned gradually, the remnant stream may fill the former channel with point bar deposits even as its flow declines. Thus, while abandoned channels often become depressions with heavy soils, abandoned courses are more likely to be fairly continuous with the point bar deposits of the original stream, or to become part of the meander belt of a smaller stream.

**Natural levees.** A natural levee forms where overbank flows result in deposition of relatively coarse sediments (sand and silt) adjacent to the stream channel. The material is deposited as a continuous sheet that thins with distance from the stream, resulting in a relatively high ridge along the bankline and a gradual backslope that becomes progressively more fine-grained with distance from the channel (Figure 7). Along the modern Mississippi River, natural levees rise about 4.5 m above the elevation of the adjacent floodplain and may extend for several kilometers or more from the channel. Natural levees formed by smaller streams or over short periods of time tend to be proportionately smaller, but the dimensions and composition of natural levee deposits are the product of various factors, including sediment sources and the specific mode of deposition. Natural levees may be deposited in association with sheetflow or as a series of crevasse splays, which are deltaic deposits formed by small channels that breach the existing natural levee during high flows.

A different type of crevasse splay occurs where man-made levees have been breached during major floods. These splays may be very extensive; have an irregular, hummocky surface; and are composed of very coarse sediments. They are the result of very high velocity flows, because the initial levee break releases water that has a surface elevation much higher than the adjacent land surface. Often the point at which the levee failed is marked by a deep scour pool, commonly called a "blue hole."

## Soils

Parent materials of soils in the Delta Region of Arkansas are fluvial sediments. The alternating periods of meander belt development and glacial outwash deposition produced complex but characteristic landforms where sediments were sorted to varying degrees based on their mode and environment of deposition. The sorting process has produced textural and topographic gradients that are fairly consistent on a gross level and result in distinctive soils. Generally, within a Holocene meander belt, surface substrates grade from relatively coarse-textured, well-drained, higher elevation soils on natural levees directly adjacent to river channels through progressively finer textured, and less well-drained materials on levee backslopes and point bar deposits to very heavy clays in closed basins such as large swales and abandoned channels. Backswamp deposits between meander belts also are filled with heavy clays. Valley train deposits typically have a topstratum (upper 0.2–3 m) of fine-grained material (clays and silts) that blankets the underlying network of braided channels and interfluves. On older, higher valley train deposits, the topstratum contains considerable loess, and in some areas consists of sandy dunes. The lowest, most recent valley trains have surface soils that are derived primarily from Mississippi River flooding (Brown et al. 1971; Saucier 1994).

The gradient of increasingly fine soil textures from high-energy to low-energy environments of deposition (natural levees and point bars to abandoned channels and backswamps) implies increasing soil organic matter content, increasing cation exchange capacity, and decreasing permeability. However, all of these patterns are generalizations, and quite different conditions occur regularly. The nature of alluvial deposition varies between and within flood events, and laminated or localized deposits of varying textures are common within a single general landform. Thus, natural levees dominated by coarse-textured sediments may contain strata with high clay content, and valley train surfaces that are usually fine-grained may have some soil units with high sand content. Point bar deposits, which typically have less organic matter incorporated into the surface soils than backswamps or abandoned channels, may actually contain more total organic matter on a volume basis due to the presence of large numbers of buried logs and other stream-transported organic material (Saucier 1994).

Within the Holocene meander belts, soils of older meander belts are likely to show greater A soil horizon development than soils in equivalent positions within younger meander belts (Autin et al. 1991). Similarly, older soils are likely to be more acidic and deeper, show less depositional stratification and more horizonation, and otherwise exhibit characteristics of advanced soil development not seen in soils of younger meander belts. The classification of soils in the region reflects the importance of soil age and related development at the highest classification level (Soil Order). Alfisols are the oldest and most developed soils, Entisols the most recent deposits with the least development, and Inceptisols are of intermediate age and development. At the Suborder level, degree of wetness is a major classification factor, and at lower levels of classification the characteristics of specific soil horizons are among the principal discriminating factors. A brief overview of the principal soil associations within the Delta Region of Arkansas is presented in Table 4.

It should be noted that the classification of soils within the Lower Mississippi Valley has been undergoing considerable modification recently. However, the existing soil surveys do not reflect these changes; therefore, the classification and terminology used in this discussion remain consistent with the existing published resources. Detailed updated digital soils maps are provided in Appendix E. Individual soil series descriptions can be found on the Web at <http://soils.usda.gov/technical/classification/scfile/index.html>.

## Vegetation

The Delta Region of Arkansas is in the west-central portion of the Mississippi Alluvial Plain Ecoregion (Omernik 1987; USEPA 1998). It is included in the Mississippi Alluvial Plain Section of the Southeastern Evergreen Forest Region by Braun (1950), and is classified as the Southern Floodplain Forest Type by Kuchler (1969). Forests of the basin are referred to as bottomland hardwoods, a term that incorporates a wide range of species and community types that can tolerate inundation or soil saturation for at least some portion of the growing season (Wharton et al. 1982).

<b>Table 4</b> <b>Classification of the Principal Soil Associations of the Delta Region of Arkansas</b>		
Map Units	Principal Landscape Settings Within the Delta	Characteristics
<b>Alfisols: Soils that are medium to high in bases and have gray to brown A horizons and B horizons of clay accumulation.</b>		
DeWitt-Stuttgart	Pleistocene Alluvial Terraces (Prairie Complex).	Deep, somewhat poorly drained and moderately well drained, very slowly permeable, level to gently sloping, silty or clayey soils of the Grand Prairie.
Loring	Pleistocene Alluvial Terraces (Prairie Complex).	Deep, moderately well-drained, moderately slowly permeable, nearly level to moderately steep loamy soils of the Grand Prairie.
Foley-Jackport-Overcup	Valley Trains and Pleistocene Alluvial Terraces adjacent to the Cache River.	Deep, poorly drained and somewhat poorly drained, very slowly permeable, level to nearly level, loamy and clayey soils.
Calloway-Henry-Grenada-Calhoun	Pleistocene Valley Trains and Prairie Complex Terraces.	Deep, moderately well drained to poorly drained, slowly permeable, level to moderately sloping, loamy soils of older valley train deposits and prairie terraces
Dundee-Bosket-Dubbs	Pleistocene Valley Trains and dune fields.	Deep, somewhat poorly drained and well drained, moderately slowly permeable and moderately permeable, level to gently sloping, loamy soils.
Amagon-Dundee	Natural levees within Holocene meander belts of the White, Black, St. Francis, and other tributaries to the Mississippi River.	Deep, poorly drained and moderately poorly drained, slowly permeable and moderately slowly permeable, level to nearly level, loamy soils on bottom lands.
Rilla-Hebert	Natural levees within Holocene meander belts of the Arkansas River.	Deep, well-drained and somewhat poorly drained, moderately permeable and moderately slowly permeable, level to gently sloping soils on bottomlands.
<b>Inceptisols: Soils that have weakly differentiated horizons; materials in the soil have been altered or removed but have not accumulated.</b>		
Sharkey-Alligator-Tunica	Backswamp deposits within Holocene meander belts of the Mississippi River.	Deep, poorly drained, very slowly permeable, level to nearly level soils on bottomlands.
Sharkey-Steele	Point bar and backswamp deposits within Holocene meander belts of the St. Francis River.	Deep, poorly drained and moderately well drained, very slowly permeable, level to nearly level, clayey and sandy soils on broad flats and undulating areas of floodplains.
Kobel	Backswamp deposits within Holocene meander belts of the White, Black, St. Francis, and other tributaries to the Mississippi River.	Deep, poorly drained, very slowly permeable, level to nearly level, clayey soils on bottomlands.
Perry-Portland	Backswamp deposits within Holocene meander belts of the Arkansas River.	Deep, poorly drained and somewhat poorly drained, very slowly permeable, level to nearly level soils on bottomlands.
Roxanna-Dardanelle-Bruno-Roellen	Various environments of deposition within the modern meander belt of the Arkansas River.	Deep, excessively drained to poorly drained, rapidly permeable to slowly permeable, level to nearly level, loamy, sandy, and clayey soils.
<b>Entisols: Soils that have little or no evidence of development of pedogenic horizons.</b>		
Crevasse-Bruno-Oklaired	Various environments of deposition within the modern meander belt of the Arkansas River.	Deep, excessively drained and well-drained, rapidly permeable and moderately rapidly permeable, sandy and loamy soils.
Commerce- Sharkey- Crevasse-Robinsonville	Various environments of deposition within the modern meander belt of the Mississippi River.	Deep, poorly drained to excessively drained, very slowly permeable to rapidly permeable, level to gently undulating, clayey, loamy, and sandy soils.
Note: Based on Saucier 1994; U.S. Department of Agriculture National Resources Conservation Service, Soil Survey Division (2002); U.S. Department of Agriculture Soil Conservation Service and Mississippi Agricultural and Forestry Experiment Station (1974); U.S. Department of Agriculture Soil Conservation Service and University of Arkansas Agricultural Experiment Station (1982).		

Bottomland hardwood forests are among the most productive and diverse ecosystems in North America. Under presettlement conditions they were essentially continuous throughout the Lower Mississippi Valley, and they interacted with the entire watershed, via floodwaters, to import, store, cycle, and export nutrients (Brinson et al. 1980; Wharton et al. 1982). Although these conditions have changed dramatically in modern times (see following section, "Alterations to Environmental Conditions"), the remaining forests still exist as a complex mosaic of community types that reflect variations in alluvial and hydrologic environments. Within-stand diversity varies from dominance by one or a few species to forests with a dozen or more overstory species, and diverse assemblages of understory, ground cover, and vine species (Klimas 1988; Putnam 1951; Wharton et al. 1982). These forests support a detritus-based trophic network that includes numerous resident and migratory wildlife species that are adapted to the highly dynamic and diverse environment (Fredrickson 1978; Wharton et al. 1982).

Most major overviews of bottomland hardwood forest ecology emphasize the relationship between plant community distribution and inundation, usually assuming that floodplain surfaces that occupy different elevations in relation to a river channel reflect different flood frequency, depth, and duration (e.g., Brinson et al. 1981; Larson et al. 1981; Wharton et al. 1982). This leads to classification of forests in terms of hydrologic "zones," each zone having characteristic plant communities. In most cases, the authors employing zonal classification systems acknowledge that parallel bands of vegetation rarely exist, and that most floodplains are geomorphically complex and support mosaics of communities. Nevertheless, zonal characterization systems generally reference most sites to a presumed stream entrenchment process that leaves a sequence of terraces, and they often regard features such as natural levees as relatively minor components of the landscape (e.g., Larson et al. 1981). A certain degree of such sequential zonation relative to flood frequency occurs in some major stream drainages within the Mississippi Alluvial Valley, such as the Cache River in Arkansas (Smith 1996). However, zonal concepts have limited utility in much of the Arkansas Delta where Pleistocene landforms and multiple abandoned Holocene meander belts dominate the landscape. In addition, features such as natural levees and abandoned channels, which may be rather minor components of some southeastern floodplains, are major deposits that occupy thousands of square kilometers in the Delta Region of Arkansas. In much the same way, the general zonal models imply that the principal hydrologic controls on community composition are flood frequency, depth, and duration, as indicated by elevation relative to a stream channel. However, stream flooding is just one of many important sources of water in the wetlands of the Arkansas Delta, and factors such as ponding of precipitation may be more important than flooding effects in many landscape settings.

Despite the complexity of the landscape and the misleading nature of zonal models of plant community distribution, plant communities do occur on recognizable combinations of site hydrology and geomorphology within the Delta Region of Arkansas. The synthesis documents of Putnam (1951) and Putnam et al. (1960) adopt a perspective that recognizes the unique terrain of the Mississippi Alluvial Valley, and summarize the principal combinations of landscape setting, drainage characteristics, and flood environment as they

influence plant community composition. Table 5 is based on that approach. Table 6 equates Putnam's (1951) community types with corresponding community designations in the most commonly referenced forest classification system, the Society of American Forester (SAF) cover types (Eyre 1980).

<b>Table 5</b> <b>Composition and Site Affinities of Common Forest Communities in the Delta Region of Arkansas (after Putnam 1951)</b>		
Forest Cover Type	Characteristic Species	Site Characteristics
Sweetgum - Water Oaks	<i>Liquidambar styraciflua</i> <i>Quercus nigra</i> <i>Quercus nuttallii</i> <i>Quercus phellos</i> <i>Ulmus americana</i> <i>Celtis laevigata</i> <i>Fraxinus pennsylvanica</i>	In first bottoms except for deep sloughs, swamps, fronts, and poorest flats. Also on terrace flats.
White Oaks - Red Oaks - Other Hardwoods	<i>Quercus michauxii</i> <i>Quercus similis</i> <i>Quercus pagoda</i> <i>Quercus shumardii</i> <i>Quercus falcata</i> var. <i>falcata</i> <i>Fraxinus americana</i> <i>Carya</i> spp. <i>Nyssa sylvatica</i> <i>Ulmus alata</i>	Fine, sandy loam and other well-drained soils on first bottom and terrace ridges.
Hackberry - Elm - Ash	<i>Celtis laevigata</i> <i>Ulmus americana</i> <i>Fraxinus pennsylvanica</i> <i>Carya aquatica</i> <i>Quercus phellos</i>	Low ridges, flats, and sloughs in first bottoms, terrace flats, and sloughs. Occasionally on new lands or fronts.
Overcup Oak - Water Hickory	<i>Quercus lyrata</i> <i>Carya aquatica</i>	Poorly drained flats, low ridges, sloughs, and backwater basins with tight soils.
Cottonwood	<i>Populus deltoides</i> <i>Carya illinoensis</i> <i>Platanus occidentalis</i> <i>Celtis laevigata</i>	Front land ridges and well-drained flats.
Willow	<i>Salix nigra</i>	Front land sloughs and low flats.
Riverfront Hardwoods	<i>Platanus occidentalis</i> <i>Carya illinoensis</i> <i>Fraxinus pennsylvanica</i> <i>Ulmus americana</i> <i>Celtis laevigata</i> <i>Acer saccharinum</i>	All front lands except deep sloughs and swamps.
Cypress - Tupelo	<i>Taxodium distichum</i> <i>Nyssa aquatica</i> <i>Nyssa sylvatica</i> var. <i>biflora</i>	Low, poorly drained flats, deep sloughs, and swamps in first bottoms and terraces.

Under natural conditions, forest stands within the Delta Region of Arkansas undergo change at various temporal and spatial scales. Primary succession occurs on recently deposited substrates, which include abandoned stream channels, point bars, crevasse splays, and abandoned beaver ponds. One familiar example is the colonization of new bars adjacent to river channels by pioneer species such as black willow (*Salix nigra*), which are replaced over time by other species such as sugarberry (*Celtis laevigata*) and green ash (*Fraxinus pennsylvanica*), and eventually by long-lived, heavy-seeded species such as oaks and hickories (Meadows and Nowacki 1996; Putnam et al. 1960). Although this sequential replacement does occur, it is actually a complex process that includes changes in the elevation

**Table 6**  
**Correspondence Between Forest Cover Types in the Delta Region of Arkansas (Putnam 1951) and Standard Society of American Foresters Forest Cover Types**

SAF Forest Cover Types	Type No.	Putnam's Cover Type
Cottonwood	63	Cottonwood
Willow Oak - Water Oak - Diamondleaf (Laurel) Oak	88	Sweetgum - Water Oaks
Swamp Chestnut Oak- Cherrybark Oak	91	White Oaks - Red Oaks - Other Hardwoods
Sweetgum - Willow Oak	92	Sweetgum - Water Oaks
Sugarberry - American Elm - Green Ash	93	Hackberry - Elm - Ash
Sycamore - Sweetgum - American Elm	94	Riverfront Hardwoods
Black Willow	95	Willow
Overcup Oak - Water Hickory	96	Overcup Oak - Bitter Pecan
Baldcypress	101	Cypress - Tupelo
Baldcypress - Tupelo	102	Cypress - Tupelo
Water Tupelo - Swamp Tupelo	103	Cypress - Tupelo

and composition of the substrate as colonizing plants and flood flows interact to induce sedimentation, and on a longer term scale, as soils mature and river channels migrate away from the site and cease delivering new sediments. In the Arkansas Delta, creation and colonization of new point bars are limited because many streams have been channelized or their banks have been stabilized, both of which reduce channel migration and recruitment of sediments.

The typical natural regeneration process in established forest stands is initiated by single tree-falls, periodic catastrophic damage from fire or windstorm, and inundation mortality due to prolonged growing-season floods or beaver dams. Small forest openings occur due to windthrow, disease, lightning strikes, and similar influences that kill individual trees or small groups of trees (Dickson 1991). The resulting openings are rapidly colonized, but the composition of the colonizing trees may vary widely depending on factors such as existing advanced reproduction, seed rain from adjacent mature trees, and importation of seed by animals or floodwaters. Often, this pattern results in small, even-aged groves of trees, sometimes of a single species (Putnam et al. 1960).

In presettlement conditions, fire may have been a significant factor in stand structure, but the evidence regarding the extent of this influence is unclear. Putnam (1951) stated that southern bottomland forests experience a "serious fire season" every 5–8 years, and that fires typically destroy much of the understory and cause damage to some larger trees that eventually provides points of entry for insects and disease. Similarly, it is difficult to estimate the influence of beaver in the presettlement landscape, because they were largely removed very early in the settlement process. However, it is likely that the bottomland forest ecosystem included extensive areas that were affected by beaver and were dominated by dead timber, open water, marsh, moist soil herbaceous communities, or shrub swamp at any given time.

## Alterations to Environmental Conditions

The physical and biological environment of the Delta Region of Arkansas has been extensively altered by human activity. Isolation and stabilization of the Mississippi and Arkansas Rivers have effectively halted the large-scale channel migration and overbank sediment deposition processes that created and continually modified the Holocene landscapes of the Arkansas Delta (Smith and Winkley 1996). At the same time, sediment input to depressions and sub-basins within the area has increased manyfold in historic times due to erosion of uplands and agricultural fields (Barnhardt 1988; Saucier 1994; Smith and Patrick 1991). The Mississippi River no longer overwhelms the landscape with floods that course through the basin, but it continues to influence large areas through back-water flooding. Patterns of land use and resource exploitation have had differential effects on the distribution and quality of remaining forest communities. Assessment of wetland functions in this highly modified landscape requires an understanding of the scope of the more influential changes that have taken place.

### Land use and management

Natural levees, which commonly are the highest elevations in the landscape of the Delta Region and often are in direct proximity to water, have been the focus of human settlement during both prehistoric and historic times (Saucier 1994). At the time of the first European explorations of the Arkansas Delta in the 16<sup>th</sup> century, natural levees of the Mississippi and Arkansas Rivers were extensively used for maize agriculture by Native Americans (Hudson 1997). By the time detailed surveys of the Mississippi River were first made in the 1880s, European settlers were farming nearly all of the natural levees adjacent to the river through the Delta (Mississippi River Commission 1881–1897). Lower terrain had not been similarly developed (Barry 1997).

In the last two decades of the 19<sup>th</sup> century, local flood control and drainage efforts began to have widespread effects in the Delta, and railroads were constructed in formerly remote areas. These changes allowed logging and agricultural development to proceed on a massive scale throughout the Lower Mississippi Valley. In the period between 1880 and 1920, nearly all virgin forests in the Arkansas Delta were cut over (Smith et al. 1984). As the 20<sup>th</sup> century progressed, improvements to farming equipment and crops and the initiation of coordinated Federal flood control efforts allowed further conversion of forested land to agriculture. From an estimated original area of 9 to 10 million hectares, Mississippi Alluvial Valley forests had been reduced by about 50 percent by 1937, and currently less than 25 percent of the original area remains forested (Smith et al. 1993). In the Arkansas Delta, the losses are more dramatic – only about 15 percent of approximately 3.2 million original wetland hectares remains. Much of the remaining forest is highly fragmented, with the greatest degree of fragmentation occurring on drier sites (such as natural levees), and the largest remaining tracts being in the wettest areas, such as the White and Cache River lowlands (Creasman et al. 1992; Rudis 1995). Nearly all of the remaining forests within the basin have been harvested at least once, and many have been cut repeatedly and are in degraded condition due to past high-grading practices (Putnam 1951; Rudis and Birdsey 1986).

The near-total loss of certain wetland types, the extreme reductions and fragmentation of others, and the degradation of forest structure and composition in the remaining forests have had wide-reaching and little-understood effects on various ecosystem characteristics in the region. For example, the differential conversion of higher, drier riverfront sites to agriculture may be a major contributing factor in the near disappearance of the extensive stands of cane, which many early travelers remarked upon as common features of the natural levees (Remsen 1986; Dickson 1991). In turn, the loss of the canebrakes may have contributed to the extinction of Bachman's warbler (*Vermivora bachmanii*), which likely was dependent on cane thickets for some parts of its life cycle. Other wildlife species, such as the now-extinct ivory-billed woodpecker (*Campephilus principalis*), apparently required old-growth forest (Remsen 1986; Tanner and Hamel 2001), and mammals with large home ranges such as cougars (*Felis concolor*) and black bears (*Ursus americanus*) were no doubt adversely affected by forest fragmentation and isolation.

Of the remaining wetland acreage in the Delta, most of the largest tracts are in public hands or under easements that give public agencies some degree of control over management decisions. Federal lands include some wetlands in the National Forest System and wetlands owned or managed under easement by the Natural Resources Conservation Service. However, the largest units are in the National Wildlife Refuge system administered by the U.S. Fish and Wildlife Service. The largest of these refuges is the 64,000-ha White River National Wildlife Refuge. State-controlled lands include those in the state park system, and more than 70,000 ha in Wildlife Management Areas located throughout the Delta, which are operated by the Arkansas Game and Fish Commission (Demas and Demcheck 1996). Some of the most intact and unique wetlands in the region are under the protection of the Arkansas Natural Heritage Commission, a division of the Department of Arkansas Heritage, which owns or has easements on more than a dozen forested wetland sites in the Delta (Arkansas Natural Heritage Commission 1997). Various private landowners, including commercial timberland operations, and non-government organizations such as The Nature Conservancy, Ducks Unlimited, and the Audubon Society, also own, manage, or otherwise work to protect forested wetlands in the Delta.

Many of these public and private organizations have been particularly involved in wetland restoration in recent years. Schoenholtz et al. (2001) reported that between 1968 and 1998 nearly 16,000 ha of forested wetlands were planted in the Arkansas Delta in the State Wildlife Management Areas and by the U.S. Fish and Wildlife Service and the Natural Resources Conservation Service. A particularly effective effort, the Wetlands Reserve Program conducted by the Natural Resources Conservation Service, has been responsible for restoration of approximately 36,000 ha of Delta wetlands between 1994 and early 2002.<sup>1</sup>

In addition to restoring some of the lost wetland acreage in the Delta, various public and private entities concerned with Delta wetlands also are addressing the problems related to differential losses of certain wetland types, lack of old growth forest, and fragmentation of the remaining forests in the region. Initiatives that recognize the importance of landscape-scale management of remaining

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<sup>1</sup> Personal Communication, January 2002, Jody Pagan, NRCS Arkansas WRP Coordinator.



large tracts include the Cache-Lower White Rivers Joint Venture developed under the North American Waterfowl Management Plan, which is intended to protect the largest contiguous block of forested wetland in the Lower Mississippi Valley outside the Atchafalaya Basin. This area also is recognized as a wetland of international significance under the Ramsar Convention of 1971 (Demas and Demcheck 1996). Similarly, the Arkansas Natural Heritage Commission and The Nature Conservancy have developed a White River-Lower Arkansas River Megasite Plan, which addresses the potential to coordinate restoration and management activities over an ecosystem encompassing nearly half a million hectares, about half of which is in public ownership (Lynch et al. 1992). On a broader scale, six Arkansas State agencies are members of the Arkansas Multi-Agency Wetland Planning Team (MAWPT), which has an overall goal "to preserve, conserve, enhance, and restore the acreage, quality, biological diversity and ecosystem sustainability of Arkansas' wetlands for citizens present and future." With the assistance of funding provided by the USEPA, this goal has been pursued through a variety of initiatives, including efforts to characterize the composition, function, and landscape patterns of wetlands in Arkansas (e.g., this guidebook), to provide public information and education, and to improve governmental participation in wetland-related decision-making. A major product of this effort is a set of Wetland Planning Area reports emphasizing wetland preservation and restoration potential on a watershed scale (Arkansas Multi-Agency Wetland Planning Team 1997).

## Hydrology

The hydrology of the Delta Region of Arkansas has been modified extensively and purposefully. Isolated wetlands associated with the higher alluvial terraces (such as Grand Prairie) and with the valley train terraces were not subject to major river flooding in historic times, and they could be readily drained with simple ditch systems, or used as sumps to collect drainage. The lowlands were far more difficult to convert to agricultural uses. By the mid-19<sup>th</sup> century, many individual plantations along the Mississippi River were protected with low levee systems, often built with slave labor, that were sufficient to exclude most floods, but not the periodic catastrophic event (Barham 1964; Barry 1997). Additional drainage and levee-building were accomplished under the provisions of the Federal Swamp Lands Act passed in 1849 and 1850 (Holder 1970), but the first truly extensive and effective efforts were undertaken in the late 19<sup>th</sup> century and into the first few decades of the 20<sup>th</sup> century, when numerous local levee and drainage districts were created and funded by land taxes and the sale of bonds, with the St. Francis Basin the focus of the most concerted activity (Barham 1964; Moore 1972; Sartain undated). In Mississippi County alone, the local interests constructed more than 1,600 km of ditches, and effectively drained and cleared nearly the entire county. However, even with this level of effort, the St. Francis Basin included some areas that defied drainage efforts, and today several large blocks of forested wetlands remain, mostly under the control of the Arkansas Game and Fish Commission.

The Arkansas River lowlands, which encompass most of the Delta south of the Grand Prairie, also were ditched and drained by local interests. Those drainage districts embarked on some ambitious projects, such as the construction of an

extensive levee system and floodgate to protect the Bayou Meto Basin from floods originating on the Arkansas River (Holder 1970). That levee was later incorporated into the Federal levee system constructed along the lower Arkansas River.

Of the major lowland basins in the Arkansas Delta, only the Lower White River area escaped wholesale reclamation efforts by the early 20<sup>th</sup> century local drainage districts. Effective drainage was simply impossible in the face of the combined influence of regular flooding on streams within the basin, such as Bayou DeView and the Cache, Black, and White Rivers, and periodic backwater flooding due to high water on the Mississippi. Not until the 1970s did effective drainage and levee construction start to bring about large-scale changes in land use, but by then environmental concerns had begun to influence public policy in the region and wholesale agricultural conversion was averted (Foti 1993). As a result, the lower basin continues to support the extensive forested wetlands of the Cache and White River National Wildlife Refuges, described previously.

Despite the successes of the early drainage districts, their efforts could not overcome the effects of the Mississippi and Arkansas Rivers in flood stage; and periodic widespread destruction occurred with major flood events (Barry 1997). These have been addressed primarily through a massive Federal effort conducted by the U.S. Army Corps of Engineers: the Mississippi River and Tributaries Project (MR&T), which is the largest flood-control project in the world (U.S. Army Engineer Division, Mississippi Valley, 1998). In order to understand the extent to which hydrology has been modified in the Delta Region of Arkansas and the way the remaining wetlands receive and move water, it is essential to understand the development and current status of the MR&T.

Corps of Engineers activities in the Lower Mississippi Valley through most of the 1800s focused principally on survey and engineering efforts relating to navigation improvement (Barry 1997). Surveys began on the Arkansas River in 1833, and by the end of the 1880s all major streams in the Arkansas Delta had been surveyed. During this same period, an extensive program of snagging was pursued on the Arkansas River, as well as clearing of forests or individual trees (potential future snags) along the banks and some dredging. Less extensive efforts were also pursued on some other Delta streams, notably the White River. But all of these efforts were piecemeal, and not all streams in the region or the Lower Mississippi Valley received the same level of attention (Clay 1986; Rathburn 1990).

In 1879, Congress authorized the creation of the Mississippi River Commission to oversee a coordinated Federal effort, to be carried out by the Corps of Engineers, to provide reliable navigation throughout the entire Mississippi River system (Moore 1972). Over the next 5 decades, the authority of the Commission was expanded, and its jurisdiction gradually enveloped various tributary stream systems. But in the early 20<sup>th</sup> century, flood control remained largely a local responsibility, and by 1927, the existing levees and related works were believed to be providing effective protection from Mississippi River floods, as well as effective drainage for communities and farmlands throughout the entire lower valley (Barry 1997).

A devastating flood in 1927 showed that the flood protection works were inadequate, and the Flood Control Act of 1928 authorized the Corps of Engineers to implement a new and comprehensive plan for preventing flooding in the Lower Mississippi Valley. The approach included construction of larger and stronger levees as well as various channel modifications, bank protection works, and other features. The multiple elements of this plan and its subsequent modifications are collectively referred to as the MR&T (Moore 1972).

Congress directed changes to the MR&T plan in the 1930s and 1940s that included the addition of cutoffs, tributary reservoirs, and an emphasis on maintenance of a stable, deep Mississippi River channel as a levee protection measure and to provide navigation benefits. In the 1950s, 1960s, and 1970s the project was expanded to include numerous tributary modifications, pump stations, harbor improvement projects, and lock and dam projects, as well as channel and levee projects throughout the system. During this latter period, fish and wildlife considerations also became authorized project purposes. Meeting fish and wildlife objectives generally involved constructing water control structures within floodways and sump areas to allow habitat management for waterfowl (Moore 1972).

With the advent of the National Environmental Policy Act (NEPA) in 1969 and other environmental legislation, proposed modifications to the MR&T were subject to more complex planning and coordination requirements than previously existed. Actions likely to adversely affect fish, wildlife, wetland ecosystems, and other natural resources have been reevaluated to identify ways to avoid or minimize environmental impacts (Moore 1972; Bolton and Metzger 1998). Compensation for impacts deemed unavoidable has included acquisition and restoration of many thousands of acres of forest within the project area, as well as construction of additional water management facilities to benefit wildlife, particularly waterfowl (Young 1998). Maintenance of existing project features continues, and additional authorized features are under construction or in planning stages (Bolton and Metzger 1998).

The cornerstone of the Federal flood-control effort in the Lower Mississippi Valley is the mainstem levee system, which is essentially continuous on the western side of the Mississippi River from Cape Girardeau, MO, to Venice, LA, about 16 km above the mouth of the river, except where tributaries enter. On the eastern bank it is discontinuous, because bluffs near the river make the levee unnecessary in some reaches. The levee system on the south bank of the Arkansas River extends about 140 km from Pine Bluff to the mainstem Mississippi River levee, and on the north bank it extends from North Little Rock approximately 90 km to a point south of Gillett. Another large Federal ring levee protects the White River Backwater Area between Helena and the mouth of the White River, and about 80 km of levees protect towns along the lower White River itself. Federal efforts in the St. Francis Basin continued the work of the local drainage districts and included several hundred kilometers of levees, plus floodways, ditches, and channel modifications. Much of the St. Francis Basin as well as the White River Backwater Area are intended to be used as water storage basins during major Mississippi River floods, and both have been fitted with pumping stations to evacuate waters trapped within the levee systems. Additional flood-control projects remain authorized under the MR&T project, including a channel modification and pump construction project currently in the planning

process for the Bayou Meto Basin. Some other elements of the MR&T have been set aside due to disinterest on the part of local sponsors or public opposition. One major change was deauthorization of a series of extensive channel modifications planned for the lower Cache River, which instead became part of the National Wildlife Refuge System (Clay 1986; Mississippi River Commission 1970; Moore 1972; Williams 1986).

River engineering influences on the Arkansas Delta involve numerous other projects, including huge reservoir systems in the Ozarks and Ouachitas, channel modifications to streams of all sizes, and local levee systems. All of these clearly have significantly influenced wetland hydrology. Often, however, river engineering causes changes to wetlands that are less apparent. Navigation works may affect the hydrology of wetlands by changing the surface elevation of river reaches behind lock and dam structures and by altering the geometry of the river channel where dredging occurs, or where channel constriction structures are employed to scour a narrow, deep channel. More fundamental changes are effected by bank stabilization projects that prevent channel meandering, which is the mechanism by which new wetlands are created within active stream meander belts (Klimas 1991).

In addition to major engineering projects, the water that enters the modern Arkansas Delta is rerouted, stored, and exported from the system in complex patterns that can result in more or less water available to remaining wetlands. For example, the uneven annual distribution of rainfall makes both drainage and supplemental irrigation common agricultural practices (Brown et al. 1971). Drainage accomplished by ditching may dry up some wetlands, but cause others to receive excessive amounts of water when they are used as sumps to which adjacent fields drain. Drainage achieved by land leveling removes the subtle microtopography that sustains many wetlands by storing precipitation, and the accelerated runoff may adversely affect downslope or downstream systems. A variety of Delta wetlands may have some dependence on groundwater, but groundwater withdrawals for irrigation and other agricultural purposes have caused depletion of the aquifer in many areas. The alluvial aquifer of the Lower Mississippi Valley is one of the largest and most heavily used freshwater sources in the United States (Saucier 1994). Overuse can cause changes in water availability and water quality (Terry et al. 1979), and may adversely affect wetlands where they are maintained by discharge from unconfined aquifers. Currently, the groundwater supply in much of the Arkansas Delta is being depleted faster than it is replenished. More than half of the Delta has been designated or proposed for designation as a "critical groundwater area," and the remainder of the region remains under study to determine if the "critical" designation is applicable (Arkansas Soil and Water Conservation Commission 2001).

## **Definition and Identification of the HGM Classes and Subclasses**

Brinson (1993a) identified five wetland classes based on hydrogeomorphic criteria, as described in Chapter 2. Pilot studies conducted in 1997 and 1998 indicated that wetlands representing four of these classes (Flat, Riverine,

Depression, and Fringe wetlands) and a variety of subclasses occur within the Delta Region of Arkansas. However, categorical separation of these classes is sometimes difficult because of the complexity of the landscape and hydrology within the basin and because features of wetlands intergrade and overlap among types. Therefore, a set of specific criteria has been established to assist the user in assigning any particular wetland in the Arkansas Delta to the appropriate class, subclass, and community type. These criteria are presented in the form of dichotomous keys in Figures 10 and 11. In addition, each wetland type identified in the keys is described in the following section, which also includes a series of block diagrams illustrating the major wetland types and their relationships to various landforms and man-made structures. These relationships also are summarized in Table 7.

Some of the criteria that are used in the keys in Figures 10 and 11 require some elaboration. For example, a fundamental criterion is that a wetland must be in the 5-year floodplain of a stream system to be included within the Riverine Class. This return interval is regarded as sufficient to support major functions that involve periodic connection to stream systems. It was also selected as a practical consideration, because the hydrologic models used to develop flood return interval maps generally include the 5-year return interval.

The classification system recognizes that certain sites functioning primarily as fringe or depression wetlands also are regularly affected by stream flooding, and therefore have a riverine functional component. This is incorporated in the classification system by establishing "river-connected" subclasses within the Fringe and Depression Classes.

The classification system addresses a major confounding aspect of overlap among wetland types that arises from the characteristic topographic variation within certain wetland types. Sites that function primarily as riverine wetlands and flats often incorporate small, shallow depressions, sometimes characterized as vernal pools and microdepressions. These features are regarded as normal components of the riverine and flat ecosystems, and are not separated into the Depression Class unless they meet specific criteria. Other significant criteria relating to classification are elaborated in the wetland descriptions in the following paragraphs.

The following sections briefly describe the classification system developed for this guidebook for wetlands in the Delta Region of Arkansas. The system includes the four principal wetland classes that occur in the Delta, each of which comprises a number of subclasses and community types. All of the Delta wetland types are described, but assessment models and supporting reference data were developed for only a subset of these types, as described in Chapter 4. Additional details, including photos and distribution maps, for each of the wetlands described, as well as wetlands in the other regions of the state, can be found on the Arkansas Multi-Agency Wetland Planning Team Web site (<http://www.mawpt.org/>).

### Key to Wetland Classes in the Delta Region of Arkansas

1. Wetland is not within the 5-year floodplain of a stream.....	2
1. Wetland is within the 5-year floodplain of a stream.....	3
2. Topography generally flat, principal water source is precipitation.....	Flat
2. Topography is depressional, or within the 5-year floodplain of a stream.....	3
3. Wetland is not in a topographic depression or impounded.....	Riverine
3. Wetland is in a topographic depression, or impounded.....	4
4. Wetland is associated with a beaver impoundment, or with a shallow impoundment managed principally for wildlife (e.g., greentree reservoirs or moist soil units).....	Riverine
4. Wetland is in an impoundment or depression other than above.....	5
5. Wetland is associated with a water body that has permanent water more than 2 m deep in most years.....	Fringe
5. Wetland is associated with a water body that is ephemeral, or less than 2 m deep in most years.....	Depression

Figure 10. Key to the wetland classes in the Delta Region of Arkansas

#### Class: Flat

Flats have little or no gradient, and the principal water source is precipitation. There is minimal overland flow into or out of the wetland except as saturated flow. Wetlands on flat areas that are subject to stream flooding during a 5-year event are classified as Riverine. Small ponded areas within flats are considered to be normal components of the Flat Class if they do not meet the criteria for the Depression Class. Sites are considered to be Slope wetlands rather than Flats if they have sufficient gradient to cause runoff in a single direction (however, slope wetlands are rare in the Delta), and as Slope or Depression wetlands if groundwater discharge is the principal water source within the wetland. There are two subclasses and six community types in the Flat Class, all of which occur within the Delta Region.

Figure 12 illustrates common landscape positions where wetlands in the Flat Class are found. See Figure 7 to identify land surfaces.

Key to Wetland Subclasses and Community Types in the Delta Region of Arkansas		
CLASS: FLAT	Subclass	Community Type
1. Soil reaction acid.....	Non-Alkali Flat (2)	
1. Soil reaction circumneutral to alkaline (lake bed deposits).....	Alkali Flat (3)	
2. Vegetation dominated by graminoids.....		<i>wet tallgrass prairie</i>
2. Vegetation dominated by woody species		
2a. Vegetation dominated by pine.....		<i>pine flat</i>
2b. Vegetation dominated by post oak.....		<i>post oak flat</i>
2c. Vegetation dominated by hardwoods other than post oak.....		<i>hardwood flat</i>
3. Vegetation dominated by graminoids.....		<i>alkali wet prairie</i>
3. Vegetation dominated by post oak.....		<i>alkali post oak flat</i>

Figure 11. Key to the wetland subclasses and community types in the Delta Region of Arkansas (Sheet 1 of 3)

CLASS: RIVERINE	Subclass	Community Type
1. Wetland associated with low-gradient stream (Stream Orders > 6, or other alluvial streams).....3		
1. Wetland associated with mid-gradient stream (Stream Orders 4-6).....	Mid-gradient Riverine (2)	
2. Water source primarily overbank flooding or lateral saturation.....		mid-gradient floodplain
2. Water source primarily backwater flooding, wetland typically located at confluence of two streams.....		mid-gradient backwater
3. Wetland not an impoundment.....	Low-gradient Riverine (5)	
3. Wetland an impoundment.....	Riverine Impounded (4)	
4. Wetland impounded by beaver.....		beaver complex
4. Wetland impounded for wildlife management (greentree reservoirs and moist soil units).....		managed wildlife impoundments
5. Water source primarily overbank flooding (5-year zone) that falls with stream water levels, or lateral saturation from channel flow.....		low-gradient overbank
5. Water source primarily backwater flooding or overbank flows (5-year zone) that remain in the wetland due to impeded drainage after stream water levels fall.....		low-gradient backwater

Figure 11. (Sheet 2 of 3)



CLASS: DEPRESSION		Subclass	Community Type
1. Depression not subject to direct stream flooding during a 5-year event; precipitation, runoff, and groundwater are the dominant inflows.....		2	
1. Depression has significant direct stream inflows and outflows relative to stored volume and/or is influenced by overbank or backwater flooding during a 5-year event.....		4	
2. Depression discharges water to surface channels, but has no significant surface inflows relative to discharge .....		Headwater Depression	headwater swamp
2. Depression has no significant direct surface outlet to a stream channel, or outflows are minor relative to stored volume.....		Isolated Depression (3)	
3a. Precipitation-dominated depression in dune fields.....			sandpond
3b. Depressional feature in abandoned meander features (oxbows or swales) not subject to 5-year flood flows.....			unconnected alluvial depression
3c. Depressional feature in relict glacial outwash channel .....			valley train pond
4. Significant, perennial streamflow enters and leaves depression.....		Not Depression Class: see Riverine Class	
4. Depression not subject to perennial flow, but receives overbank or backwater flooding during 5-year events.....		Connected Depression	floodplain depression
CLASS: FRINGE		Subclass	Community Type
1. Wetland on the margin of a man-made reservoir.....		Reservoir Fringe	reservoir shore
1. Wetland on the margin of water body other than a reservoir.....		2	
2. Water body subject to stream flooding during 5-year flood events.....		Connected Lacustrine Fringe	connected lake margin
2. Water body not subject to flooding during a 5-year event.....		Isolated Lacustrine Fringe	unconnected lake margin

Figure 11. (Sheet 3 of 3)

**Table 7**  
**Hydrogeomorphic Classification of Forested Wetlands in the Delta Region of Arkansas**  
**and Typical Geomorphic Settings of Community Types**

Wetland Classes, Subclasses, and Communities	Typical Geomorphic Setting
<b>CLASS: FLAT</b>	
SUBCLASS: ALKALI FLAT	
Alkali Post Oak Flat	Lacustrine sediments deposited in lake systems impounded by glacial outwash.
SUBCLASS: NON-ALKALI FLAT	
Hardwood Flat	Backswamp and point bar environments on Pleistocene and Holocene meander-belt topography, and on interfluvies on valley trains.
Post Oak Flat	Pleistocene terraces.
<b>CLASS: RIVERINE</b>	
SUBCLASS: MID-GRADIENT RIVERINE	
Mid-Gradient Floodplain	Point bar and natural levee deposits within active meander belts of streams transitioning from uplands to alluvial plain, or dissecting terrace deposits.
Mid-Gradient Backwater	Backswamp and point bar deposits within active meander belts of mid-gradient streams near point of confluence with major alluvial river.
SUBCLASS: LOW-GRADIENT RIVERINE	
Low-Gradient Overbank	Point bar and natural levee deposits within active meander belts of alluvial streams.
Low-Gradient Backwater	Backswamp, point bar, and low-lying valley train deposits within and between both active and inactive meander belts of alluvial streams.
SUBCLASS: IMPOUNDED RIVERINE	
Beaver Complex	All flowing waters.
Wildlife Management Impoundment	Various settings.
<b>CLASS: DEPRESSION</b>	
SUBCLASS: HEADWATER DEPRESSION	
Headwater Swamp	In relict outwash channel, adjacent to scarp of a higher valley train terrace.
SUBCLASS: ISOLATED DEPRESSION	
Sand Pond	Eolian sand deposits (dunefields) on valley trains.
Valley Train Pond	Depressions atop buried braided outwash channels on valley trains.
Unconnected Alluvial Depression	Abandoned channels and large swales in former and current meander belts of larger rivers (including both Holocene and Pleistocene meander belt deposits).
SUBCLASS: CONNECTED DEPRESSION	
Floodplain Depression	Abandoned channels and large swales in former and current meander belts of larger rivers.
<b>CLASS: FRINGE</b>	
SUBCLASS: ISOLATED LACUSTRINE FRINGE	
Unconnected Lake Margin	Abandoned channels in meander belts and adjacent to man-made impoundments.
SUBCLASS: CONNECTED LACUSTRINE FRINGE	
Connected Lake Margin	Abandoned channels in meander belts and adjacent to man-made impoundments.

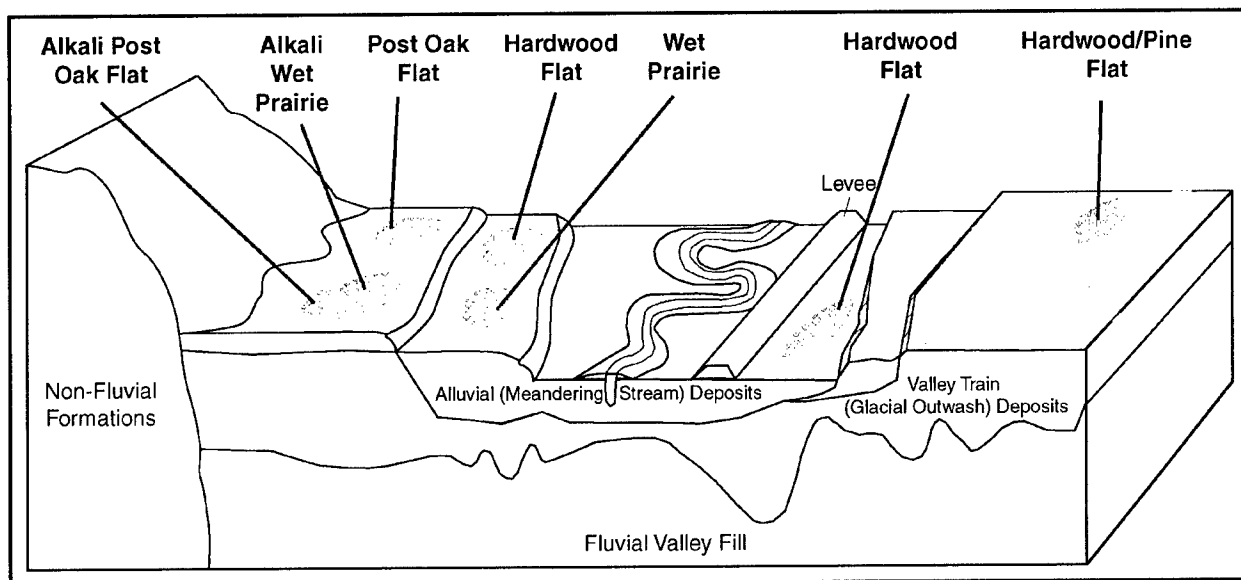


Figure 12. Common landscape positions of wetland community types in the Flat Class

**Subclass: alkali flat.** Alkali flats (also called sodic or saline flats) have soils with high pH and high levels of sodium or magnesium salts in or near the surface layer. They typically have very poor drainage and a shallow hardpan. The combination of impeded drainage and unusual soil chemistry restricts the potential plant communities, and provides habitats for certain rare species. The two community types in this subclass are separated based on predominant vegetation, but in fact probably represent a continuum of change in soil conditions, where the forested community occurs on soils with deeper hardpans than the prairie community. Most sites with alkali soils are believed to be former Pleistocene lake beds.

Alkali flats are not common in the Delta, and assessment models applicable to these types are not presented in this guidebook. They are more common in the Coastal Plain Region, and will be addressed in the HGM Guidebook for that region.

**Community types.** The following communities occur within the alkali flats subclass:

- a. *Alkali post oak flat.* Alkali post oak flats occur on sites where the soils have extremely poor drainage and concentrations of salts accumulate near or on the soil surface. These sites are believed to have been occupied by shallow lakes during the Pleistocene Epoch, when waning and waxing periods of continental glaciation to the north of Arkansas created temporary lakes within the modern Delta Region. Repeated filling and drying of the lakes caused salts to accumulate, and today the ancient lakebeds are flats that support unique wetlands with characteristic plants that are tolerant of the high salt concentrations and impeded drainage conditions. In most cases, alkali flats are a mosaic of prairie and unvegetated “slick spots” on soils with salts at or very near the surface, while soils with less surface salt or somewhat better drainage support stunted

post oak trees. Alkali post oak flats have been reported from the Delta region (St. Francis County), and likely occur in other locations where soils are strongly saline.

- b. *Alkali wet prairie.* The ancient Pleistocene lake beds that support alkali post oak flats also support small areas of alkali wet prairie (also called saline prairie) where soil salinity is highest or drainage is very poor. Where the salts accumulate on the surface, it is common to find a hard white or gray surface, termed a “slick spot.” These areas may have salt crystals visible on the surface during dry periods, and they are largely devoid of vegetation. The perimeter of the slick spot often supports a crust of lichens, mosses, and liverworts. In Arkansas, the endangered plant species *Geocarpon minimum* is almost entirely restricted to this slick spot perimeter zone in alkali wet prairies, although it has not been reported from prairies in the Delta Region. Beyond the slick spot edge, prairie species are able to colonize as the depth to the zone of concentrated salts increases, and stunted trees and shrubs occur on still deeper soils. Species of three-awn (*Arstida* spp.) are particularly characteristic grasses of these communities.

**Subclass: non-alkali flat.** Flats with neutral and acid soils can support a variety of community types. They are differentiated based on predominant vegetation types, which generally reflect drainage conditions. Fire history may also be an important factor in certain instances. These wetlands are widely distributed within the Delta, and provide habitat for numerous plant and animal species. Because wet flats are maintained by precipitation rather than flooding, many were relatively easy to convert to agriculture with fairly minor changes to drainage conditions, and extensive flat areas have been cleared. In addition, many sites that were historically subject to regular flooding have been isolated from streamflows by modern man-made levees, and these sites are now classified as flats.

This guidebook includes assessment models applicable to all of the forested non-alkali flats in the Delta Region. Assessment models were not developed for the wet tallgrass prairie type, for which few high-quality reference sites could be located in the Delta. Until such models are developed based on reference sites in other regions of Arkansas, tallgrass prairie wetlands are best assessed using a strictly floristic approach and site-specific evaluation of the drainage, soils, management programs, and proposed impacts.

**Community types:** The following communities are found in non-alkali flats:

- a. *Wet tallgrass prairie.* The wet tallgrass prairie community type typically occurs within broad basins or headwater draws that have poor drainage, or in minor swales within larger expanses of dry prairie. All of these sites tend to stay wet, with areas of standing surface water, through spring. They usually become extremely dry in late summer. Wet tallgrass prairie is dominated by typical prairie species such as big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), and numerous perennial forbs. However, it also includes wetland species

such as beakrush (*Rhynchospora* spp.), marsh fleabane (*Pluchea foetida*), sundews (*Drosera* spp.) and sphagnum moss (*Sphagnum* spp.). Wet prairie is also likely to support species that are rare or unusual in Arkansas, such as prairie cordgrass (*Spartina pectinata*). Fire is essential to maintain prairies in Arkansas — without fire, trees will gradually establish. The original extent of prairie in Arkansas has been dramatically reduced by agriculture, development, fire control, and forest management practices. In the Delta, remnant wet prairies are found primarily in the Grand Prairie area (Lonoke and Prairie Counties).

- b. *Pine flat*. Pine flats, also called pine flatwoods, are common in the Coastal Plain, but in the Delta they are restricted to a relatively small area in the vicinity of Pine City in Monroe County. There, they occur on valley train deposits, on silt loam soils that are acid to strongly acid and with a high water table throughout the winter and spring. In the modern landscape, most of these sites have been dramatically altered by forest management, drainage, and by changes in fire frequency, timing, and intensity. The remaining examples in relatively good condition have large loblolly pines, but even these sites generally have a large hardwood component, characterized by sweetgum and a variety of oaks.
- c. *Hardwood flat*. Hardwood flats occur on fairly level terrain that is not within the 5-year floodplain of stream systems, but nevertheless remains wet throughout winter and spring due to rainfall that collects in small shallow pools. These pools often refill and remain wet for days or weeks following summer rains. In the Delta region, hardwood flats often are dominated by Nuttall oak (*Quercus nuttallii*) in Holocene environments, and by water or willow oaks on older surfaces, where they are sometimes called oak flatwoods. Numerous other species occur on hardwood flats and may dominate.
- d. *Post oak flat*. Post oak flats occur on clay soils with poor drainage, generally on the margins of the Grand Prairie, where they may intergrade with hardwood flats, but are distinctively dominated by post oak or Delta post oak. These sites are saturated to the surface in the wet season and following rains, but become extremely dry and hard in summer. Mima (or pimple) mounds often are present, and contribute to the extensive ponding on these sites by impounding rainwater and impeding runoff. The understory and groundcover are sparse, which results in a parklike appearance in many stands, and many post oak flats probably were savanna when frequently burned prairies were widely distributed on the Grand Prairie. Tree growth tends to be very slow, although trees are not stunted as they are on alkali post oak flats.

### **Class: Riverine**

Riverine wetlands are those areas directly flooded by streamflow, including backwater and overbank flow, at least once in five years on average (i.e., they are within the five-year floodplain). Depressions and fringe wetlands that are within the 5-year floodplain are not included in the Riverine Class, but beaver ponds and wildlife management impoundments are usually considered to be riverine. Riverine wetlands encompass many different types of wetland communities;

there are three subclasses and six community types in the Riverine Class in the Delta (Table 7, Figure 13).

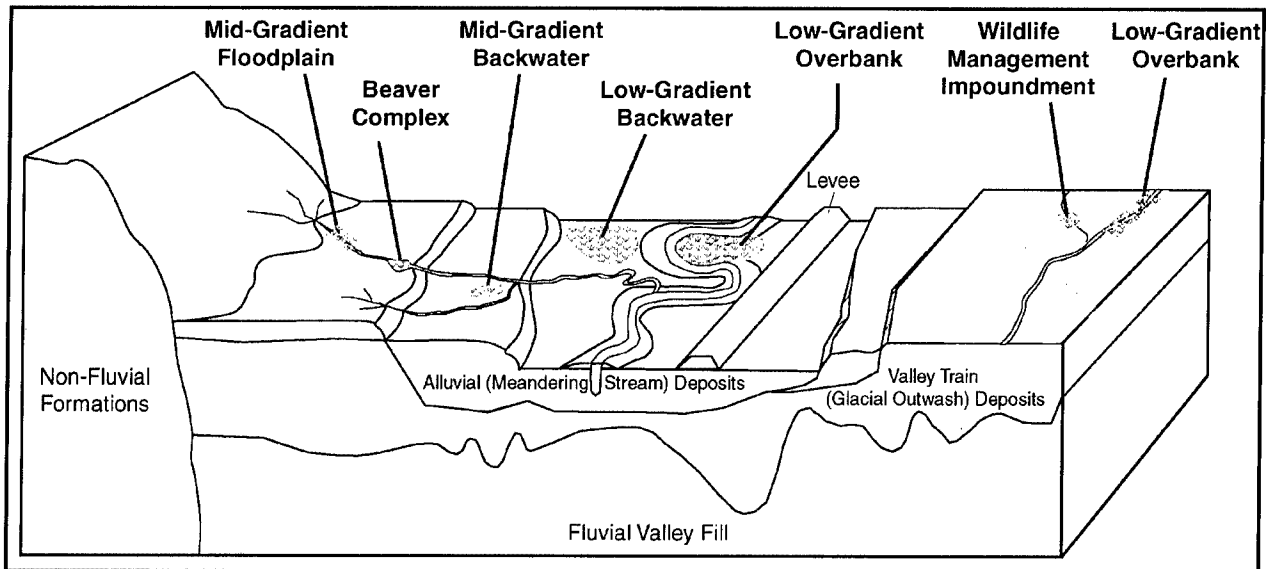


Figure 13. Common landscape positions of wetland community types in the Riverine Class

**Subclass: mid-gradient riverine.** Mid-gradient riverine wetlands are associated with streams (typically 4th – 6th order) that have significant floodplain development, but are upstream of the meandering portion of a stream system. They are important sources for input of organic material to the stream system. Mid-gradient systems are of limited distribution in the Delta, being restricted to sites transitional to the Coastal Plain, Ozarks, and Ouachitas, and to some parts of the drainages flanking the Grand Prairie and Crowley's Ridge.

Due to the limited distribution of mid-gradient riverine systems in the Delta and consequent limited extent of potential reference wetlands for this subclass, no specific applicable assessment models have been developed for this guidebook. However, applicable models will be presented in the HGM Guidebooks for the Coastal Plain, Ouachitas, and the Ozarks, and can be used for adjacent mid-gradient sites in the Delta.

**Community types.** The following community types occur within the mid-gradient riverine subclass:

- a. *Mid-gradient floodplain.* Mid-gradient floodplain wetlands occur along small streams with significant bar and floodplain formation. Riparian wetlands along mid-gradient streams are usually fairly small floodplain units that occur repeatedly, often alternating from one side of the channel to the other. They combine elements of upland and lowland forests, and can be highly diverse. Species such as river birch (*Betula nigra*), red maple (*Acer rubrum*), American elm (*Ulmus americana*), and green ash are characteristic.
- b. *Mid-gradient backwater.* Mid-gradient backwater wetlands occur at the confluence of streams where high flows on the larger channel cause

backwater flooding in the lower reaches of the mid-gradient tributary. They are sites where sediments accumulate rapidly, building natural levees and creating extensive backwater areas that drain slowly. Mid-gradient backwater systems tend to support plant communities that are more tolerant of flooding and sedimentation than the communities on most other mid-gradient floodplains. Species typical of adjacent hill-slopes are not successful within the backwater zone, and some portions of the floodplain are occupied by species, such as baldcypress (*Taxodium distichum*), that are more typical of lowland swamps.

**Subclass: low-gradient riverine.** Low-gradient riverine wetlands occur within the 5-year floodplain of meandering streams (usually 7th order or higher). They include a wide variety of community types, and have important functions related to habitat as well as sediment and water storage.

**Community types.** The following community types occur within the low-gradient riverine subclass:

- a. *Low-gradient backwater.* Low-gradient backwater wetlands occupy sites that flood frequently (1- to 5-year flood frequency), but flooding is primarily by slack water, rather than by the high-velocity flows that predominate in overbank flood zones. Backwater flooding usually occurs when mainstem streams are in high stages, impeding the discharge of tributaries and causing them back up onto their floodplains. This results in sediment accumulation and ponding that persists long after water levels have fallen in the stream channels. Sediments tend to be fine-grained, with considerable accumulation of organic material. Backwater sites that flood for long durations and are very poorly drained are usually dominated by overcup oak (*Quercus lyrata*) and water hickory (*Carya aquatica*). Less flooded sites are often dominated by green ash, Nuttall oak or willow oak (*Quercus phellos*), and the driest backwater sites may have species such as water oak (*Quercus nigra*) and cherrybark oak (*Quercus pagoda*) as important components in the overstory. As with flats, vernal pools may be an important component of the low-gradient backwater community type. Many sites that were subject to backwater flooding in historic times are now protected by levees. Wetlands on these altered sites are classified as flats.
- b. *Low-gradient overbank.* Low-gradient overbank wetlands occur on regularly flooded sites (1- to 5-year flood frequency zone) along or near streambanks and on bars and islands within channel systems. These sites are usually point bar deposits, often with a natural levee veneer. This type differs from the low-gradient backwater community type because floodwater usually moves through the overbank zone at moderate to high velocities, parallel to the channel. Sediments, nutrients, and other materials are exported downstream or imported from upstream sites differently than they are in backwater wetlands. Backwater sites may tend to accumulate fine sediments and organic material and to export dissolved materials in the water column. Overbank sites tend to be subject to scour or deep deposition of coarse sediments, and litter and other detritus may be completely swept from a site or accumulated in large debris piles.

In-channel sandbars and riverfront areas usually are dominated by willows, sycamore (*Platanus occidentalis*), cottonwood, and similar pioneer species, while older and less exposed substrates support more diverse communities. In most cases, however, plant communities in the overbank flood zone tend to be dominated by species with broad tolerances for inundation, sedimentation, and high-velocity flows. Overbank sites sometimes include vernal pools, usually in the form of long, arched swales between the depositional ridges of meander-scroll topography, rather than the irregularly shaped pools typically found in backwater areas.

**Subclass: impounded riverine.** These wetlands occur in shallow impoundments that detain and slow stream flows, but generally remain flow-through systems. They include highly dynamic and unique beaver-dominated wetlands, as well as systems that are intensively managed to benefit particular groups of wildlife species.

There are no HGM models specific to beaver complexes, but the recommended approach is to regard them as a fully functional component of any riverine system being assessed. See Chapter 6, "Special Issues in Applying Assessment Results," for a discussion of how to handle beaver complexes within the context of a functional assessment.

Wildlife Management Impoundments are designed specifically to maximize a single wetland function (habitat) and often are targeted toward a specific wildlife group (usually waterfowl). They are intended to allow managers to flood large areas at times when water is not naturally present in those areas. Because the hydrological modifications usually imposed do not reflect the patterns observed in reference systems, this guidebook does not include models designed specifically for application to managed impoundments.

**Community types.** The following community types occur within the impounded riverine subclass:

- a. *Beaver complex.* Beaver complexes were once nearly ubiquitous here and elsewhere in the continental United States, but became relatively uncommon during the past two centuries following the near-extirpation of beaver. In their most common form, they consist of a series of impounded pools on flowing streams. Beaver cut trees for dams and food, and they have preferences for certain species (e.g., sweetgum (*Liquidambar styraciflua*)), which alters the composition of forests within their foraging range. Tree cutting and tree mortality from flooding create patches of dead timber surrounded by open water, shrub swamps, or marshes. Beaver complexes may be abandoned when the animals exhaust local food resources or when they are trapped out. Following abandonment, the dams deteriorate, water levels fall, and different plants colonize the former ponds. When beaver reoccupy the area, the configuration changes again, the result being that systems with active beaver populations are in a constant state of flux.
- b. *Wildlife management impoundment.* Wildlife management impoundments are areas managed specifically to provide habitat for waterfowl



and other waterbirds. There are two versions of this management approach: greentree reservoirs and moist soil units. They are included in the Riverine Class because they usually draw water from and return it to stream systems, but the wetlands are contained within low levee systems that allow managers to create shallow flooding conditions suitable for use by foraging and resting birds. Greentree reservoirs are leveed sections of mature oak bottomland forest, which provide access to acorns and forest invertebrates when artificially flooded to provide shallow water for waterfowl foraging. Moist soil units are leveed cleared fields where water management and farm machinery are employed to maintain marshlike conditions, which provide small seeds and different invertebrates than are found in forested wetlands.

### **Class: Depression**

Depression wetlands occur in topographic low points where water accumulates and remains for extended periods. Sources of water include precipitation, runoff, groundwater, and stream flooding.

Depressions (both isolated and connected) are distinguished from the ponded areas that occur within the Flat and Riverine Subclasses in several ways. Depressions tend to occur in abandoned channels, abandoned courses, and large point bar swales, while vernal pools within Flat and Riverine wetlands occur in minor swales or in areas bounded by natural levee deposits. Depressions hold water for extended periods due to their size, depth, and ability to collect surface and subsurface flows from an area much larger than the depression itself. They tend to fill during the winter and spring, and dry very slowly. Prolonged rains may fill them periodically during the growing season, after which they again dry very slowly. Vernal pools in Flats and Riverine settings, in contrast, fill primarily due to direct precipitation inputs and dry out within days or weeks. Depression Subclass wetlands usually exhibit two or more of the following characteristics:

- Depressional soils may have one or both of the hydric soil indicators F2 (Loamy Gleyed Matrix) or A4 (Hydrogen Sulfide) (USDA NRCS 1998).
- Depressions are distinct, closed units with relatively abrupt transitions to flats, riverine wetlands, or uplands (as opposed to extensive riverine backwater zones).
- Vegetation in depressions usually is dominated by one or more of the following species: baldcypress, water tupelo (*Nyssa aquatica*), swamp privet (*Forestiera acuminata*), water elm (*Planera aquatica*), and button-bush (*Cephalanthus occidentalis*). Many depressions are fringed (and some are dominated) by species such as overcup oak and water hickory.

In the Delta Region of Arkansas, there are three subclasses and five community types in the Depression Class (Table 7, Figure 14).

**Subclass: headwater depression.** Headwater depressions have one or more outlets that form the headwaters of perennial streams. They export materials such as nutrients and organic matter to downstream systems, and contribute to

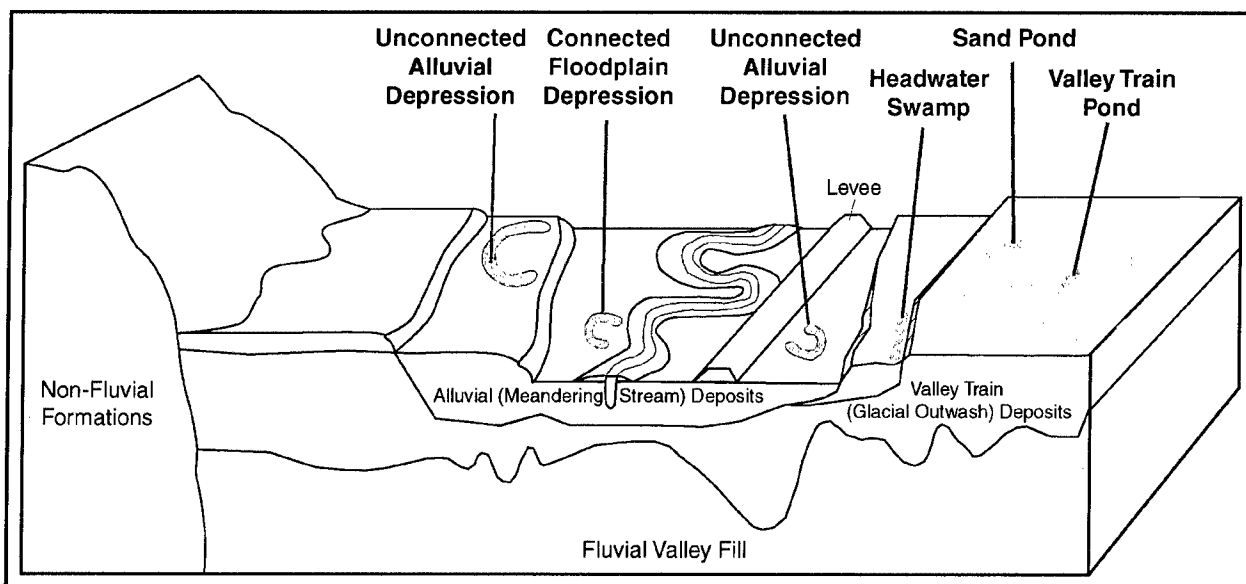


Figure 14. Common landscape positions of wetland community types in the Depression Class

maintenance of stream baseflow. They differ from Connected Depressions in that they do not have a surface stream input, but rather are fed by groundwater, precipitation, and/or local runoff.

**Community type.** The following community type occurs within the headwater depression subclass:

- a. *Headwater swamp.* Few examples of this wetland type are known, but those that have been examined appear to be restricted to basins formed in ancient glacial outwash channels that receive groundwater from adjacent higher terraces. The nearly constant water supply into the depression creates swamp conditions, where baldcypress and water tupelo are the most common tree species. Few species are present in the understory, and herbaceous species grow primarily on stumps or from a zone of mosses on tree trunks at the level where water tends to stabilize during the growing season. The perimeter forest is dominated by typical lowland species, such as green ash, overcup oak, and Nuttall oak. All known examples of this wetland type are in Monroe or Phillips Counties, including the largest example, which is located at the Louisiana Purchase State Park.

**Subclass: isolated depression.** Isolated depressions are found in a variety of landscape settings. They are maintained by precipitation, runoff, and sometimes by groundwater. Some may have small influent and outlet channels, but they are not overwhelmed by floodwaters during 5-year events; therefore, the import or export of materials is not a significant function of these wetlands except during extreme events. Their isolation from river systems may result in very different wildlife functions than those associated with connected depressions. For example, isolated depressions may lack predatory fish populations, and thereby provide vital habitat for certain invertebrate and amphibian species.

**Community types.** The following community types occur within the isolated depressions subclass:

- a. *Sand pond.* Sand ponds are depressions within dunefields. The dunes are wind-blown accumulations of sediments that were deposited in waning glacial outwash channels, and date from 12,000 and 30,000 years before present. Individual dunes typically are 3 to 5 m high, and support upland forests or have been converted to agriculture. Numerous small, enclosed depressions are confined by the dunes, resulting in a poorly drained environment that ponds rainwater and possibly intercepts local groundwater for extended durations. As a result, distinctive, isolated wetlands form that usually include swamp species such as baldcypress or water tupelo in the deepest interior areas, and successively less water-tolerant species around the perimeter of the depression. Many sand ponds, particularly those in the northern part of their distribution, contain the shrub species pondberry (*Lindera melissifolia*) and corkwood (*Leitneria floridana*), which do not occur commonly in any other habitat in Arkansas. Sand pond wetlands occur in several distinct bands within the Delta region, and are associated with valley train deposits.
- b. *Unconnected alluvial depression.* Unconnected alluvial depressions occur in major river floodplains that have been cut off from the channel by levees and on terraces (former floodplains that are higher than the modern floodplain). They are not affected by river flooding during common flood events (1- to 5-year flood frequency zone). This lack of connection to the river distinguishes this wetland type from floodplain depressions, but otherwise the two types are very similar. Unconnected alluvial depression wetlands typically occur in abandoned river channels and large swales. Depressions that are deep enough to hold water year-round will have an open-water zone (less than 2 m deep) in the center, with baldcypress and buttonbush in areas that are rarely dry, and relatively narrow zones of progressively “drier” plants, such as overcup oak, around the depression perimeter. Many of these wetlands have been altered by agricultural activities including drainage works that either reduce or increase water storage within the depression.
- c. *Valley train pond.* Valley train ponds are isolated wetlands associated with glacial outwash (“valley train”) deposits. They form in very shallow basins that are the remnants of ancient braided channel systems. Plant species in valley train ponds on the youngest outwash deposits (e.g., much of the St. Francis basin) are similar to those found in the alluvial depressions of active stream meander belts, such as baldcypress and water tupelo. Ancient sandbars within the valley train depressions may support species that are not commonly seen in swamps, but are more typical of sandy riverfront areas, such as sycamore and river birch. Older valley train deposits, where outwash channels are largely filled by stream backwater sediments, loess, or erosion from surrounding surfaces, have fewer, shallower ponds than younger surfaces, and tend to be dominated by species less tolerant of water such as willow and water oaks. Water sources for valley train ponds may include groundwater connections through the subsurface, sand-filled paleo-channel system, in addition to precipitation and local runoff. Valley train ponds have been described on

outwash deposits between the White River and Crowley's Ridge, and in the St. Francis River lowlands.

**Subclass: connected depression.** Connected depressions occur within the 5-year floodplain of streams, and are integral components of the stream ecosystem with regard to materials exchange and storage. They often are used by fish and other aquatic organisms that move in and out of the wetland during floods.

**Community type.** The floodplain depression is the sole community type described within the connected depression subclass:

- a. *Floodplain depression.* Floodplain depression wetlands are most commonly found in remnants of abandoned stream channels, or in broad swales left behind by migrating channels. They are usually near the river, and are flooded by the river during the more common (1- to 5-year) flood events. They typically support swamp forests or shrub swamps in deeper water zones that remain flooded most of the time, and overcup oak-water hickory forests in areas that dry out in summer. Floodplain depression wetlands were once common in the Delta, but as effective flood-control works have been developed along major rivers, many depressions have become isolated from stream systems and now function as unconnected alluvial depressions (discussed previously).

### **Class: Fringe**

Fringe wetlands occur along the margins of lakes. By convention, a lake must be more than 2 m deep; otherwise associated wetlands are classified as Depressional.

In Arkansas, natural lakes occur mostly in the abandoned channels of large rivers (oxbows), but numerous man-made impoundments also support fringe wetlands. Typical examples within the Delta include the baldcypress fringe common on oxbow lakes, or the black willow fringe that is often associated with borrow pits. There are three subclasses and three community types in the Fringe Class (Table 7, Figure 15). No assessment models have been developed for any of the Fringe wetland subclasses in Arkansas, primarily because no single reference system can reflect the range of variability they exhibit. In particular, many water bodies that support fringe wetlands are subject to water-level controls, but the resulting fluctuation patterns are highly variable depending on the purpose of the control structure.

**Subclass: reservoir fringe.** Wetlands that occur within the fluctuation zone of man-made reservoirs are classified as Reservoir Fringe. Reservoirs are distinguished from other man-made water bodies (such as borrow pits) in that they are specifically constructed and operated to store water for flood control, water supply, or similar purposes. As a result, they tend to have fluctuation regimes that are different from any natural pattern in the region.

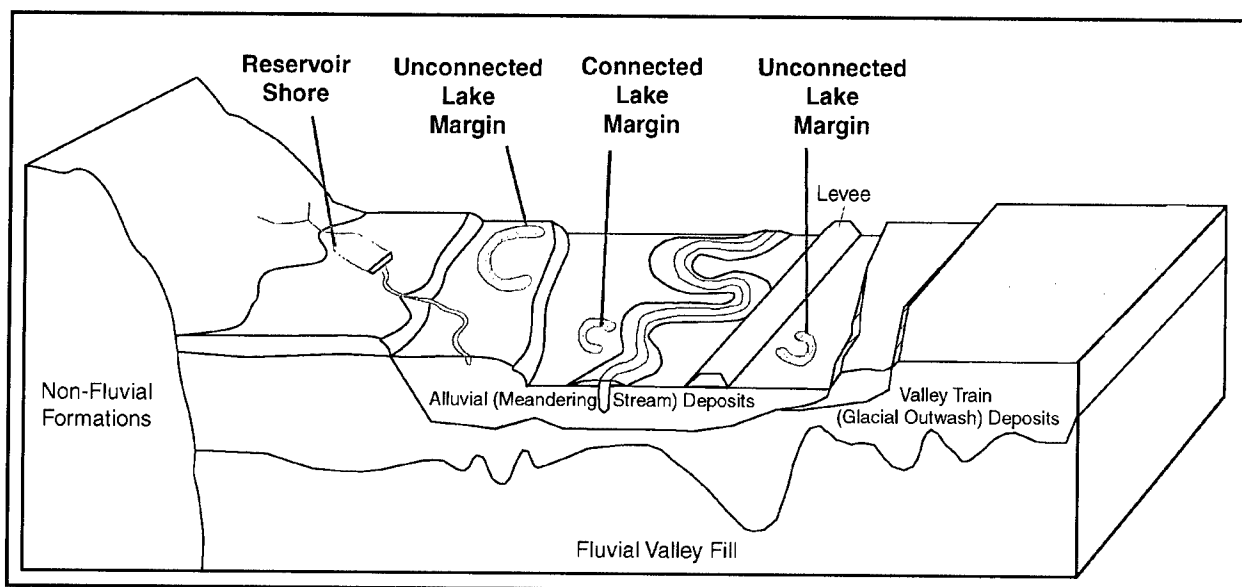


Figure 15. Common landscape positions of wetland community types in the Fringe Class

**Community type.** The reservoir shore is the sole community type described within the reservoir fringe subclass:

- a. *Reservoir shore.* Man-made reservoirs include a wide array of features, such as large farm ponds, municipal water storage reservoirs, and state recreational lakes. In almost all cases, these lakes are managed specifically to modify natural patterns of water flow; therefore their shoreline habitats are subjected to inundation at times and for durations not often found in nature. Steep reservoir shores usually support little perennial wetland vegetation other than a narrow fringe of cattails and rushes and willows. The most extensive wetlands within reservoirs usually occur where tributary streams enter the lake, and sediments accumulate to form deltas. These sites may be colonized by various marsh species, and sometimes black willow or buttonbush, but even these areas are vulnerable to extended drawdowns, ice accumulation, erosion due to boat wakes, and similar impacts.

**Subclass: connected lacustrine fringe.** Fringe wetlands are considered to be “connected” to other aquatic systems if they become contiguous with riverflows during a 5-year flood event. This means that aquatic organisms can move freely between the river and the lake on a regular basis; and nutrients, sediments, and organic materials are routinely exchanged between the riverine and lake systems.

**Community type:** The connected lake margin is the sole community type described in the connected lacustrine fringe subclass:

- a. *Connected lake margin.* Connected lake margin wetlands occur primarily in oxbow lakes near large rivers, where they are frequently inundated during floods (that is, they are within the 1- to 5-year flood frequency zone). Many lakes that would have met this criterion early in the 1900s have gradually been disconnected from riverflows due to the completion

of large levees and other flood-protection works, and the wetlands in those lakes are now classified as unconnected lake margins. Connected lake margins differ from unconnected systems in that they routinely exchange nutrients, sediments, and aquatic organisms with the river system. Shoreline cypress-tupelo stands and fringe marshes are common, and the upper reaches of oxbow lakes often contain buttonbush swamps and expansive marsh systems. In addition to natural oxbows, there are man-made bodies of water, such as borrow pits, that support connected fringe wetlands. Connected lake margin fringe wetlands are common along large rivers within the Delta Region.

**Subclass: isolated lacustrine fringe.** These fringe wetlands occur on lakes that are not within the 5-year floodplain of a river, although they may have small inflow and outflow streams. Many oxbow lakes that have been isolated from big rivers by levees are in this category. Managed flood-control and water supply reservoirs are not included here, but deeply flooded borrow pits are included.

**Community type.** The unconnected lake margin is the sole community type described in the isolated lacustrine fringe subclass:

- a. *Unconnected lake margin.* Unconnected lakes are lakes that are not within the portion of a floodplain that is inundated by a river on a regular basis (that is, they are not within the 1- to 5-year floodplain). They are similar in appearance to connected lake margins but are classified separately because they do not regularly exchange nutrients, sediments, or fish with river systems. Most are associated with oxbow lakes, where baldcypress wetlands normally form in a narrow band along the shoreline. Shallow filled areas in the upper and lower ends of the lake sometimes develop more extensive wetland complexes of willows, buttonbush, and marsh species.

Most of these natural lake systems have been modified in various ways. Frequently, their outlets have been fitted with control structures to allow added storage and manipulation of water. Inflows have been altered by farm drainage and other diversions, and adjacent lands have been cleared or developed in many areas. All of these actions have caused accelerated sedimentation within the lakes.

Naturally occurring unconnected lake margins are most common in the former floodplains of large rivers, especially the Mississippi and Arkansas Rivers, where levees now prevent flooding. Man-made lakes in this subclass can occur anywhere.

## 4 Wetland Functions and Assessment Models

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This Regional Guidebook contains seven sets of assessment models applicable to wetlands in the Delta Region of Arkansas. Not all of the wetland subclasses and community types described in Chapter 3 and Table 7 can be assessed using the models presented here. Only forested wetlands (or sites that could support forested wetlands) are intended to be assessed using these models. No assessment models were developed for the Alkali Flat subclass or the Mid-Gradient Riverine subclass, because relatively few examples of these wetlands exist in the Delta. Models for assessment of these systems will be presented in guidebooks for other regions of the state and will be applicable to Delta systems. Finally, none of the Fringe Class or Riverine Impounded subclass wetlands are addressed in this document. Impacts to these wetlands are likely to involve subtle changes in water level management, which are beyond the scope of a rapid field assessment technique.

The Delta wetlands that can be assessed with the models presented here include all of the subclasses and community types not specifically excluded in the preceding paragraph, and represent most of the common forested wetland types in the region. For simplicity, the Non-Alkali Flat subclass will be referred to simply as the Flat subclass for the remainder of this guidebook. Also, the Low-Gradient Riverine subclass is sufficiently complex that separate models have been developed for its constituent community types, Low-Gradient Overbank and Low-Gradient Backwater wetlands. To maintain consistency, they also will be referred to as separate subclasses for the remainder of this guidebook.

Based on this guidebook discussion, the six wetland subclasses for which assessment models are presented in this chapter are the following:

- a.* Flat.
- b.* Low-Gradient Riverine Overbank.
- c.* Low-Gradient Riverine Backwater.
- d.* Headwater Depression.
- e.* Isolated Depression.
- f.* Connected Depression.

The wetland functions that can be assessed using this guidebook were identified by participants in a workshop held in Arkansas in 1997. That group selected hydrologic, biogeochemical, and habitat functions that are important and measureable in Arkansas wetlands from a suite of potential functions identified in "A Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands" (Brinson et al. 1995). Based on the workshop recommendations, this regional guidebook provides models and reference data required to determine the extent to which forested wetlands of the Arkansas Delta perform the following functions:

- a. Detain Floodwater.
- b. Detain Precipitation.
- c. Cycle Nutrients.
- d. Export Organic Carbon.
- e. Remove Elements and Compounds.
- f. Maintain Plant Communities.
- g. Provide Habitat for Fish and Wildlife.

It should be noted that not all functions are performed by each regional wetland subclass. Thus, assessment models for each subclass may not include all seven functions. In addition, the form of the assessment model that is used to assess functions can vary from subclass to subclass.

In this chapter, each of these functions is discussed generally in terms of the following topics:

- a. *Definition and applicability.* This section defines the function, identifies the subclasses where the function is assessed, and identifies an independent quantitative measure that can be used to validate the functional index.
- b. *Rationale for selecting the function.* This section discusses the reasons a function was selected for assessment, and the onsite and offsite effects that may occur as a result of lost functional capacity.
- c. *Characteristics and processes that influence the function.* This section describes the characteristics and processes of the wetland and the surrounding landscape that influence the function, and lays the groundwork for the description of assessment variables.
- d. *General form of the assessment model.* This section presents the structure of the general assessment model and briefly describes the constituent variables.

The specific form of the assessment models used to assess functions for each regional wetland subclass and the functional capacity subindex curves are presented in Chapter 5. In the final chapter (Chapter 6), detailed descriptions are presented of assessment variables and the methods used to measure or estimate their values.



## Function 1: Detain Floodwater

### Definition and applicability

This function reflects the ability of wetlands to store, convey, and reduce the velocity of floodwater as it moves through a wetland. The potential effects of this reduction are damping of the downstream flood hydrograph, maintenance of postflood base flow, and deposition of suspended sediments from the water column to the wetland. This function is assessed for the following regional wetland subclasses in the Delta Region of Arkansas: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, and Connected Depression.

The recommended procedure for assessing this function involves estimation of “roughness” within the wetland, in addition to flood frequency. A potential independent, quantitative measure for validating the functional index is the volume of water stored per unit area per unit time ( $\text{m}^3/\text{ha}/\text{time}$ ) at a discharge equivalent to the average annual peak event.

### Rationale for selecting the function

The capacity of wetlands to temporarily store and convey floodwater has been extensively documented (Campbell and Johnson 1975; Demissie and Kahn 1993; Dewey and Kropper Engineers 1964; Dybvig and Hart 1977; Novitski 1978; Ogawa and Male 1983, 1986; Thomas and Hanson 1981). Many societal benefits related to the reduction of flood damage occur as a result of wetlands performing this function. Generally, floodwater interaction with wetlands dampens and broadens the flood wave, which reduces peak discharge downstream. Similarly, wetlands can reduce the velocity of water currents and, as a result, reduce erosion (Ritter et al. 1995). Some portion of the floodwater volume detained within floodplain wetlands is likely to be evaporated or transpired, reducing the overall volume of water moving downstream. The portion of the detained flow that infiltrates into the alluvial aquifer or which returns to the channel very slowly via low-gradient surface routes may be sufficiently delayed that it contributes significantly to the maintenance of base flow in some streams long after flooding has ceased (Saucier 1994; Terry et al. 1979). Retention of particulates also is an important component of the flood detention function because sediment deposition directly alters the physical characteristics of the wetland (including hydrologic attributes) and influences downstream water quality.

This function deals specifically with these physical influences on flow and sediment dynamics. Floodwater interaction with floodplain wetlands influences a variety of other wetland functions in the Delta Region of Arkansas, including nutrient mobility and storage and the quality of habitat for plants and animals. The role of flooding in maintenance of these functions is considered separately in other sections of this chapter.

## Characteristics and processes that influence the function

The capacity of a wetland to detain and moderate floodwaters is related to antecedent conditions, the characteristics of the particular flood event, the configuration and slope of the floodplain and channel, and the physical obstructions present within the wetland that interfere with flows. The intensity, duration, and spatial extent of precipitation events affect the magnitude of the stream discharge response. Typically, rainfall events of higher intensity, longer duration, and greater spatial extent result in greater flood peaks. Watershed characteristics such as size and shape, channel and watershed slopes, drainage density, and the presence of wetlands and lakes have pronounced effects on the stormflow response (Brooks et al. 1991; Dunne and Leopold 1978; Leopold 1994; Patton 1988; Ritter et al. 1995). The larger the watershed, the greater the volume and peak stream discharge that result from a rainfall event. Watershed shape affects how quickly surface and subsurface flows reach the outlet to the watershed. For example, a rounded watershed concentrates runoff more quickly than an elongated one and will tend to have higher peak flows. Steeper hillslopes and channel gradients also result in quicker response and higher peak flows. The higher the drainage density (i.e., the sum of all the channel lengths divided by the watershed area), the faster water is concentrated at the watershed outlet and the higher the peak flow. As the percentage of wetland area and/or reservoirs increases, the greater the flattening effect (i.e., attenuation) on the stormflow hydrograph. In general, these climatic and watershed characteristics are consistent within a given region and are considered constant for the purposes of rapid assessment.

The physical characteristics of the floodplain and the stream channel also are important determinants of flood flow interactions. The morphology of the stream channel and its floodplain reflect the discharges and sediment loads that have occurred in the past. Under stable flow and sediment conditions, the stream and its floodplain will eventually achieve equilibrium. Alteration to the stream channel or its watershed may cause instability that results in channel aggradation or degradation and a change in depth, frequency, and duration of overbank flow events (Dunne and Leopold 1978; Rosgen 1994). As the stream channel aggrades, available water storage in the channel decreases, resulting in greater depth, frequency, and duration of flooding on the floodplain, and an increase in amount of surface water stored in the wetland over an annual cycle. Conversely, as the stream channel degrades, available water storage in the channel increases, resulting in less depth, frequency, and duration of flooding and a decrease in the amount of surface water stored in the wetland over an annual cycle. The duration of water storage is secondarily influenced by the slope and roughness of the floodplain. Slope refers to the gradient of the floodplain across which floodwaters flow. Roughness refers to the resistance to flow created by vegetation, debris, and topographic relief. In general, duration increases as roughness increases and slope decreases.

Of all of these characteristics, only flood frequency and the roughness component can be reasonably incorporated into a rapid assessment. The extensive channel modifications and levee construction that have taken place in the region make it difficult to ascribe detailed flood characteristics to any particular point on the ground, especially if it is not directly adjacent to a channel and near a stream

gauge. At best, flood frequency can be estimated for some sites, at least to the extent needed to classify a wetland as riverine or connected (i.e., within the 5-year floodplain). In cases where flood frequency can be estimated more specifically, that information can be used in the assessment of this function. Otherwise, the only element of the Floodwater Detention function that is assessed is roughness.

### General form of the assessment model

The model for assessing the Detain Floodwater function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

$V_{FREQ}$  = frequency of flooding

$V_{LOG}$  = log density

$V_{GVC}$  = ground vegetation cover

$V_{SSD}$  = shrub-sapling density

$V_{TDEN}$  = tree density

The model can be expressed in a general form:

$$FCI = V_{FREQ} \times \left[ \frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right] \quad (1)$$

The assessment model has two components: frequency of flooding  $V_{FREQ}$  and a compound expression that represents flow resistance (roughness) within the wetland. The flood frequency variable is employed as a multiplier such that the significance of the roughness component is proportional to how often the wetland is inundated.

The compound expression of flow resistance includes the major physical components of roughness that can be characterized readily at the level of a field assessment. They include elements that influence flow velocity differently depending on flood depth and time of year. For example, ground vegetation cover  $V_{GVC}$  and log density  $V_{LOG}$  can effectively disrupt shallow flows. Shrub and sapling density  $V_{SSD}$  have their greatest influence on flows that intercept understory canopies (usually 1–3 m deep), and tree stems  $V_{TDEN}$  interact with a full range of flood depths. Both tree stems and logs are equally effective in disrupting flows at all times of the year, while understory and ground cover interactions are less effective during winter floods than during the growing season. Other components of wetland structure contribute to roughness, but are not assessed here because they do not commonly influence flows to the same degree as these components (e.g., snag density).

## **Function 2: Detain Precipitation**

### **Definition and applicability**

This function is defined as the capacity of a wetland to prevent or slow runoff of rainfall to streams. This is accomplished chiefly by microdepression storage, infiltration, and absorption by organic material and soils. Both flood-prone (riverine) wetlands and nonflooded wetlands (flats) are assessed for this function. Depressional wetlands also perform a precipitation storage function, but are not assessed for that function within the Delta Region of Arkansas. Precipitation storage in depressions is related to local runoff to varying degrees, and it is difficult to consistently define source areas and available storage volumes in the context of a rapid field assessment. In contrast, precipitation storage in flats and riverine wetlands is more often a local effect related to microdepressional storage and infiltration capacity. Three wetland subclasses are assessed for the precipitation detention function in the Delta Region of Arkansas: Flat, Low-Gradient Riverine Overbank, and Low-Gradient Riverine Backwater.

The recommended procedure for assessing this function is estimation of available micro-depression storage and characterization of the extent of organic surface accumulations available to improve absorption and infiltration. A potential independent direct measure would be calculation of onsite storage relative to runoff predicted by a storm hydrograph for a given rainfall event.

### **Rationale for selecting the function**

Like the floodwater detention function, capture and detention of precipitation prevent erosion, dampen runoff peaks following storms, and help maintain base-flow in streams. The stream hydrograph has a strong influence on the development and maintenance of habitat structure and biotic diversity of adjacent ecosystems (Bovee 1982; Estes and Orsborn 1986; Stanford et al. 1996). In addition, onsite storage of precipitation may be important in maintaining wetland conditions on the site, independent of the influence of flooding. The presence of ponded surface water and recharge of soil moisture also have implications for plant and animal communities within the wetland, but these effects are assessed separately.

### **Characteristics and processes that influence the function**

Flats and riverine wetlands capture precipitation and local runoff in micro-depressions and vernal pools. Microdepressions are usually formed by channel migration processes or tree wind-throw, which creates small, shallow depressions when root systems are pulled free of the soil. Vernal pools are usually found in ridge-and-swale topography, or they can be created by the gradual filling of formerly deeper depressions such as cutoffs or oxbows. In addition, the presence of surface organic accumulations reduces runoff and promotes infiltration. Therefore, sites with large amounts of microdepression and vernal pool storage and a thick, continuous litter or duff layer will most effectively reduce the movement of precipitation as overland flow. Instead, the water is detained onsite, where it

supports biological processes and contributes to subsurface water storage and eventually to maintenance of baseflow in nearby streams. Clearing of natural vegetation cover will remove the source of litter and the mechanism for developing new microdepressions. Land use practices that involve ditching or land leveling can eliminate onsite storage and promote rapid runoff of precipitation.

### General form of the assessment model

The assessment model for the Detain Precipitation function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

$V_{POND}$  = percent of area subject to ponding

$V_{OHOR}$  = O horizon thickness

$V_{LITTER}$  = thickness of the litter layer

The model can be expressed in a general form:

$$FCI = \frac{\left[ V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2} \right]}{2} \quad (2)$$

The assessment model has two components, which are weighted equally. The percentage of the assessment area subject to ponding  $V_{POND}$  is based on a field estimate. The second component expression is an average based on field measures of organic matter accumulation on the soil surface, which are represented by the thickness of the O horizon  $V_{OHOR}$  and the percentage of the ground surface covered by litter  $V_{LITTER}$ . Litter is sometimes a problematic variable to use, because it is seasonal in nature. However, litter is an important element in precipitation detention, and may be differentially exported from some riverine sites; therefore, it is included in the model despite the inherent difficulties. If users of this guidebook determine that litter cannot be estimated reliably in the wetland being assessed (for example, if fieldwork in two areas being compared will span several seasons), then litter can be removed from the model equation, and the model structure revised appropriately.

## Function 3: Cycle Nutrients

### Definition and applicability

This function refers to the ability of the wetland to convert nutrients from inorganic forms to organic forms and back through a variety of biogeochemical processes such as photosynthesis and microbial decomposition. The nutrient cycling function encompasses a complex web of chemical and biological

activities that sustain the overall wetland ecosystem, and it is assessed in all six wetland subclasses.

The assessment procedure described here utilizes indicators of the presence and relative magnitude of organic material production and storage, including living vegetation strata, dead wood, detritus, and soil organic matter. Potential independent, quantitative measures for validating the functional index include net annual primary productivity ( $\text{gm/m}^2$ ), annual litter fall ( $\text{gm/m}^2$ ), or standing stock of living and/or dead biomass ( $\text{gm/m}^2$ ).

### **Rationale for selecting the function**

In functional wetlands, nutrients are transferred among various components of the ecosystem, such that materials stored in each component are sufficient to maintain ecosystem processes (Ovington 1965; Pomeroy 1970; Ricklefs 1990). For example, an adequate supply of nutrients in the soil profile supports primary production, which makes plant community development and maintenance possible (Bormann and Likens 1970; Perry 1994; Whittaker 1975). The plant community, in turn, provides a pool of nutrients and source of energy for secondary production and also provides the habitat structure necessary to maintain the animal community (Fredrickson 1978; Wharton et al. 1981). Plant and animal communities serve as the source of detritus, which provides nutrients and energy necessary to maintain a characteristic community of decomposers. These decomposers, in turn, break down organic material into simpler elements and compounds that can then reenter the nutrient cycle (Dickinson and Pugh 1974; Harmon et al. 1986; Hayes 1979; Pugh and Dickinson 1974; Reiners 1972; Schlesinger 1977; Singh and Gupta 1977; Vogt et al. 1986).

### **Characteristics and processes that influence the function**

In wetlands, nutrients are stored within, and cycled among, four major compartments: (a) the soil, (b) primary producers such as vascular and non-vascular plants, (c) consumers such as animals, fungi, and bacteria, and (d) dead organic matter, such as leaf litter or woody debris, referred to as detritus. The transformation of nutrients within each compartment and the flow of nutrients between compartments are mediated by a complex variety of biogeochemical processes. For example, plant roots take up nutrients from the soil and detritus and incorporate them into the organic matter in plant tissues. Nutrients incorporated into herbaceous or deciduous parts of plants will turn over more rapidly than those incorporated into the woody parts of plants. However, ultimately, all plant tissues are either consumed or die and fall to the ground where they are decomposed by fungi and microorganisms and mineralized to again become available for uptake by plants.

Many of the processes involved in nutrient cycling, such as primary production and decomposition, have been studied extensively in wetlands (Brinson et al. 1981). In the southeast specifically, there is a rich literature on the standing stock, accumulation, and turnover of above- and below-ground biomass in forested wetlands (Brinson 1990; Brown and Peterson 1983; Conner and Day 1976; Day

1979; Elder and Cairns 1982; Harmon et al. 1986; Mulholland 1981; Raich and Nadelhoffer 1989; Nadelhoffer and Raich 1992; Symbula and Day 1988).

In controlled field studies, the approach for assessing nutrient cycling is usually to measure the rate at which nutrients are transformed and transferred between compartments over an annual cycle (Brinson et al. 1984; Harmon et al. 1986; Kuenzler et al. 1980), which is not feasible as part of a rapid assessment procedure. The alternative is to estimate the standing stocks of living and dead biomass in each of the four compartments and assume that nutrient cycling is taking place at a characteristic level if the biomass in each compartment is similar to that in reference standard wetlands. In this case, estimation of consumer biomass (animals, etc.) is too complex for a rapid assessment approach; thus, the presence of these organisms is assumed based on the detrital and living plant biomass components.

### General form of the assessment model

The model for assessing the Cycle Nutrients function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

- $V_{TBA}$  = tree basal area
- $V_{SSD}$  = shrub-sapling density
- $V_{GVC}$  = ground vegetation cover
- $V_{OHOR}$  = O horizon thickness
- $V_{AHOR}$  = A horizon biomass
- $V_{WD}$  = woody debris biomass
- $V_{SNAG}$  = snag density

The model can be expressed in a general form:

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2} \quad (3)$$

The two constituent expressions within the model reflect the two major production and storage compartments: living and dead organic material. The first expression is composed of indicators of living biomass, expressed as tree basal area  $V_{TBA}$ , shrub and sapling density  $V_{SSD}$ , and ground vegetation cover  $V_{GVC}$ . These various living components also reflect varying levels of nutrient availability and turnover rates, with the aboveground portion of ground cover biomass being largely recycled on an annual basis, while understory and tree components incorporate both short-term storage (leaves) as well as long-term storage (wood). Similarly, the second expression includes organic storage compartments that reflect various degrees of decay. Snag density  $V_{SNAG}$  and woody debris volume  $V_{WD}$  represent relatively long-term storage compartments that are gradually

transferring nutrients into other components of the ecosystem through the mediating activities of fungi, bacteria, and higher plants. The thickness of the O horizon  $V_{OHOR}$  represents a shorter term storage compartment of largely decomposed, but nutrient-rich organics on the soil surface. The thickness of the A horizon (actually, the portion of the A where organic accumulation is apparent)  $V_{AHOR}$  represents a longer term storage compartment, where nutrients that have been released from other compartments are held within the soil and are available for plant uptake, but are generally conserved within the system and not readily subject to export by runoff or floodwater.

All of these components are combined here in a simple arithmetic model, which weights each element equally. Note that one detrital component, litter accumulation, is not used in this model. That is because it is a relatively transient component of the onsite nutrient capital, and may in fact be readily exported. Therefore it is used as a nutrient-related assessment variable only in the carbon export function, discussed in the next section.

## **Function 4: Export Organic Carbon**

### **Definition and applicability**

This function is defined as the capacity of the wetland to export dissolved and particulate organic carbon, which may be vitally important to downstream aquatic systems. Mechanisms involved in mobilizing and exporting nutrients include leaching of litter, flushing, displacement, and erosion. This assessment procedure employs indicators of organic production, the presence of organic materials that may be mobilized during floods, and the occurrence of periodic flooding to assess the organic export function of a wetland. An independent quantitative measure of this function is the mass of carbon exported per unit area per unit time ( $\text{g/m}^2/\text{year}$ ).

This function is assessed in wetlands that have outflow to streams, which includes four subclasses in the Delta Region of Arkansas: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, Headwater Depression, and Connected Depression.

### **Rationale for selecting the function**

The high productivity of river-connected wetlands and their interaction with streams make them important sources of dissolved and particulate organic carbon for aquatic food webs and biogeochemical processes in downstream aquatic habitats (Elwood et al. 1983; Sedell et al. 1989; Vannote et al. 1980). Dissolved organic carbon is a significant source of energy for the microbes that form the base of the detrital food web in aquatic ecosystems (Dahm 1981; Edwards 1987; Edwards and Meyers 1986).



## Characteristics and processes that influence the function

Watersheds with a large proportion of riverine and other wetland types have generally been found to export organic carbon at higher rates than watersheds with fewer wetlands (Brinson et al. 1981; Elder and Mattraw 1982; Johnston et al. 1990; Mulholland and Kuenzler 1979). This is attributable to several factors: (a) the large amount of organic matter in the litter and soil layers that comes into contact with surface water during flooding; (b) relatively long periods of inundation and, consequently, contact between surface water and organic matter, thus allowing for significant leaching; (c) the ability of the labile carbon fraction to be rapidly leached from organic matter when exposed to water (Brinson et al. 1981); and (d) the ability of floodwater to transport dissolved and particulate organic carbon from the floodplain to the stream channel.

## General form of the assessment model

The model for assessing the Export Organic Carbon function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

$V_{FREQ}$  = frequency of flooding

$V_{LITTER}$  = thickness of the litter layer

$V_{OHOR}$  = O horizon thickness

$V_{WD}$  = woody debris biomass

$V_{SNAG}$  = snag density

$V_{TBA}$  = tree basal area

$V_{SSD}$  = shrub-sapling density

$V_{GVC}$  = ground vegetation cover

The general form of the assessment model follows:

$$FCI = V_{FREQ} \times \frac{\left[ \frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} \right] + \left[ \frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2} \quad (4)$$

This model is similar to the model used to assess the nutrient cycling function in that it incorporates most of the same indicators of living and dead organic matter. The living tree, understory, and ground cover components ( $V_{TBA}$ ,  $V_{SSD}$ , and  $V_{GVC}$ ) represent primarily organic production, indicating that materials will be available for export in the future. The dead organic fraction represents the principal sources of exported material, represented by litter, snags, woody debris, and accumulation of the O horizon ( $V_{LITTER}$ ,  $V_{SNAG}$ ,  $V_{WD}$ , and  $V_{OHOR}$ ). This model differs from the nutrient cycling model in that materials stored in the soil are not included due to their relative immobility, and periodic flooding is a required component of this model, because the export function is largely dependent on

inundation and continuity with riverflows. This model also includes litter as a component of the dead organic fraction, despite the fact that it is a highly seasonal functional indicator that is difficult to estimate reliably, and therefore is not included in other models where it may seem appropriate. However, it is included in this model because it represents the most mobile dead organic fraction in the wetland, and because it may be the only component of that fraction that is present in young or recently restored systems. If users of this guidebook determine that litter cannot be estimated reliably in the wetland being assessed (for example, if fieldwork in two areas being compared will span several seasons), then litter can be removed from the model equation.

## **Function 5: Remove Elements and Compounds**

### **Definition and applicability**

This function is defined as the ability of the wetland to permanently remove or temporarily immobilize nutrients, metals, and other elements and compounds that are imported to the wetland from various sources. In a broad sense, elements include macronutrients essential to plant growth (nitrogen, phosphorus, and potassium) as well as heavy metals (zinc, chromium, etc.) that can be toxic at high concentrations. Compounds include pesticides and other imported materials. The term removal means the permanent loss of elements and compounds from incoming water sources (e.g., deep burial in sediments, loss to the atmosphere), and the term sequestration means the short- or long-term immobilization of elements and compounds. A potential independent, quantitative measure of this function is the quantity of one or more imported elements and compounds removed or sequestered per unit area during a specified period of time (e.g.,  $\text{g/m}^2/\text{year}$ ).

All wetlands in the Delta Region of Arkansas are likely to perform this function to some degree. However, the indicators available to support a rapid field assessment are concerned primarily with contact between soil materials and floodwaters carrying dissolved materials. Removal of materials delivered to an area via local runoff, groundwater, or atmospheric sources is not considered as part of this assessment, primarily because of the difficulty in defining source areas. However, materials transported to the area being assessed via the stream channel can be indicated by a measurable variable, flood frequency. Therefore, this function is assessed in river-connected wetlands, which includes the following subclasses in the Delta Region of Arkansas: Low-Gradient Riverine Overbank, Low-Gradient Riverine Backwater, and Connected Depression.

### **Rationale for selecting the function**

The role of wetlands as interceptors of elements and compounds from upland or aquatic nonpoint sources is widely documented (Cooper et al. 1986; Cooper et al. 1987; Lowrance et al. 1984; Mitsch et al. 1979; Peterjohn and Correll 1984), and is an important ecosystem process moderating the movement and transformation of waterborne materials. The most apparent societal benefit of this function is that the removal and sequestration of elements and compounds by wetlands

reduce the load of nutrients, heavy metals, pesticides, and other pollutants in rivers and streams. This often translates into better water quality and aquatic habitat in rivers and streams through burial or facilitated processing of elements and compounds (e.g., denitrification).

### **Characteristics and processes that influence the function**

Elements and compounds are imported to wetlands by a variety of mechanisms and from a variety of sources. They include dry deposition and precipitation from atmospheric sources, stream flooding, overland flow, channelized flow, interflow, shallow groundwater flow, and colluvial material from upland sources. Some of these mechanisms, such as dry deposition and precipitation, typically account for a small proportion of the total quantity of elements and compounds imported to the wetland. The mechanisms that bring nutrients and compounds to the wetland from fluvial and terrestrial sources are more significant in terms of quantities of materials imported. Once nutrients and compounds arrive in the wetland, they may be removed and sequestered through a variety of biogeochemical processes. Biogeochemical processes include complexation, chemical precipitation, adsorption, denitrification, decomposition to inactive forms, hydrolysis, uptake by plants, and other processes (Faulkner and Richardson 1989; Johnston 1991; Kadlec 1985).

A major mechanism that contributes to removal of elements and compounds from water entering a wetland is reduction. Denitrification will not occur unless the soil is anoxic and the redox potential falls below a certain level. When this occurs, nitrate ( $\text{NO}_3^-$ ) removed by denitrification is released as nitrogen gas to the atmosphere. In addition, sulfate is reduced to sulfide, which then reacts with metal cations to form insoluble metal sulfides such as  $\text{CuS}$ ,  $\text{FeS}$ ,  $\text{PbS}$ , and others. Another major mechanism for removal of elements and compounds is by adsorption to electrostatically charged soil particles. Clay particles and particulate organic matter are the most highly charged soil particles and contribute the most to the CEC of the soil. Cation exchange is the interchange between cations in solution and other cations on the surface of any active material (i.e., clay colloid or organic colloid). The sum total of exchangeable cations that a soil can adsorb is the CEC. The CEC of a soil is a function of the amount and type of clay and the amount of organic matter in the soil. Further, organic matter is a food source for microbes involved in various microbial processes (i.e., reduction-oxidation reactions, denitrification, microbial pesticide degradation, etc.). Nitrogen in the ammonium ( $\text{NH}_4^+$ ) form may be sequestered by adsorption to clay minerals in the soil. Phosphorus can be only sequestered, not truly removed. The soluble orthophosphate ion ( $\text{PO}_4^{3-}$ ) may be specifically adsorbed ("fixed") to clay and Fe and Al oxide minerals (Richardson 1985), which are generally abundant in riverine wetlands. Likewise, heavy metals can be sequestered from incoming waters by adsorption onto the charged surfaces (functional groups) of clay minerals by specific adsorption onto Fe and Al oxide minerals or by chemical precipitation as insoluble sulfide compounds. Direct measurement of concentrations of these soil components is beyond the scope of rapid assessment. However, soils with pH of 5.5 or less generally have Al oxide minerals present that are capable of adsorbing phosphorus and metals. Fe oxides are reflected in brown or red in surface or subsoil horizons, either as the dominant color or as redox concentrations. If the

Fe oxide minerals become soluble by reduction, adsorbed phosphorus is released into solution. Annual net uptake of phosphorus by growing vegetation, although significant, usually represents a small quantity relative to other soil/sediment sinks of phosphorus (Brinson 1985). Riverine wetlands also retain nutrients and compounds by storing and cycling them among the plant, animal, detrital, and soil compartments (Brinson 1977; Brinson et al. 1984; Day et al. 1977; Kitchens et al. 1975; Kleiss 1996; Mitsch et al. 1979; Patrick and Tusneem 1972; Yarbro 1983; Yarbro et al. 1984).

### General form of the assessment model

The model for assessing the Remove Elements and Compounds function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

$V_{FREQ}$  = frequency of flooding

$V_{CEC}$  = cation exchange capacity

$V_{OHOR}$  = O horizon thickness

$V_{AHOR}$  = A horizon biomass

The assessment model can be expressed in a general form:

$$FCI = V_{FREQ} \times \left[ \frac{(V_{CEC} + V_{OHOR} + V_{AHOR})}{3} \right] \quad (5)$$

The variables employed in the model reflect the importance of soil characteristics and organic matter in the complex interactions that influence removal or immobilization of materials from floodwaters. The clay component of soil cation exchange capacity  $V_{CEC}$  is estimated by indirect means, and the organic fraction is estimated as the thickness of the portion of the A horizon with organic matter accumulation  $V_{AHOR}$ . In addition, the role of direct interaction with surface organic accumulations and associated microbial activity is indicated by a field estimate of the thickness of the O horizon  $V_{OHOR}$ . As noted, although these ecosystem elements influence the fate of materials arriving in the wetland from a variety of sources, this model is intended only to assess the removal and sequestration of materials arriving in floodwaters. Therefore, the flood frequency variable  $V_{FREQ}$  is employed as a multiplier of the compound expression that describes soil and organic matter conditions.

## Function 6: Maintain Plant Communities

### Definition and applicability

This function is defined as the capacity of a wetland to provide the environment necessary for characteristic plant community development and maintenance. In assessing this function, one must consider both the extant plant

community as an indication of current conditions and the physical factors that determine whether or not a characteristic plant community is likely to be maintained in the future. Various approaches have been developed to describe and assess plant community characteristics that might be appropriately applied in developing independent measures of this function. These include quantitative measures based on vegetation composition and abundance such as similarity indices (Ludwig and Reynolds 1988), and indirect multivariate techniques such as detrended correspondence analysis (Kent and Coker 1995). However, none of these approaches alone can supply a "direct independent measure" of plant community function, because they are tools that are employed in a more complex analysis that requires familiarity with the regional vegetation and collection of appropriate sample data.

This function is assessed in all six subclasses in the Delta Region of Arkansas.

### **Rationale for selecting the function**

The ability to maintain a characteristic plant community is important because of the intrinsic value of the plant community and the many attributes and processes of wetlands that are influenced by the plant community. For example, primary productivity, nutrient cycling, and the ability to provide a variety of habitats necessary to maintain local and regional diversity of animals are directly influenced by the plant community (Harris and Gosselink 1990). In addition, the plant community of a river-connected wetland influences the quality of the physical habitat, nutrient status, and biological diversity of downstream systems (Bilby and Likens 1979; Elder 1985; Gosselink et al. 1990; Hawkins et al. 1982).

### **Characteristics and processes that influence the function**

Numerous studies describe the environmental factors that influence the occurrence and characteristics of plant communities in lowland hardwood wetlands (Hodges 1997; Messina and Conner 1997; Robertson 1992; Robertson et al. 1978; Robertson et al. 1984; Smith 1996; Wharton et al. 1982). Hydrologic regime is usually cited as the principal factor controlling plant community attributes. Consequently, this factor is a fundamental consideration in the basic hydrogeomorphic classification scheme employed in this guidebook. Soil characteristics are also significant determinants of plant community composition (see "Soils" section in Chapter 3). In addition to physical factors, system dynamics and disturbance history are also important in determining the condition of a wetland plant community at any particular time. These include past land use, timber harvest history, hydrologic changes, sediment deposition, and events such as storms, fire, beaver activity, insect outbreaks, and disease. Clearly, some characteristics of plant communities within a particular wetland subclass may be determined by factors too subtle or variable to be assessed using rapid field estimates. Therefore, this function is assessed primarily by considering the degree to which the existing plant community structure and composition are appropriate to site conditions and the expected stage of maturity for the site. Secondly, in some subclasses, soil and hydrologic conditions are assessed to

determine if fundamental requirements are met to maintain wetland conditions appropriate to the geomorphic setting.

### General form of the assessment model

The model for assessing the Maintain Plant Communities function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

- $V_{TBA}$  = tree basal area
- $V_{TDEN}$  = tree density
- $V_{COMP}$  = composition of tallest woody stratum
- $V_{SOIL}$  = soil integrity
- $V_{POND}$  = microdepressional ponding

The model can be expressed in a general form:

$$FCI = \left\{ \left[ \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right] \right\} \times \left[ \frac{(V_{SOIL} + V_{POND})}{2} \right]^{1/2} \quad (6)$$

The first expression of the model has two components. One component describes the structure of the overstory stratum of the plant community in terms of tree basal area and density ( $V_{TBA}$  and  $V_{TDEN}$ ). Together these indicate whether the stand has a structure typical of a mature forest with “gap” regeneration processes in place. The second term of the expression ( $V_{COMP}$ ) considers the species composition of the dominant stratum, which will be the overstory in most instances, but which may be the shrub or ground cover layers in communities that are in earlier (or arrested) stages of development. This allows recognition of the faster recovery trajectory likely to take place in planted restoration sites (versus abandoned fields).

The second expression of the model considers two specific site factors that may be crucial to plant community maintenance under certain conditions.  $V_{SOIL}$  is a simple comparison of the soil on the site to the mapped or predicted soil type for the area and geomorphic setting. As described in the section “Vegetation” in Chapter 3, plant communities of the Delta Region of Arkansas are strongly affiliated with particular soil types, which in turn are the product of distinct alluvial processes. The  $V_{SOIL}$  variable allows recognition of sites where the native soils have been replaced or buried by sediments inappropriate to the site, or where the native soils have been damaged significantly, as by compaction. The  $V_{POND}$  variable focuses on a specific aspect of site alteration—the removal of microtopography and related ponding of water on flats and riverine wetlands. As described previously, ponding of precipitation is a crucial mechanism for maintaining wetland character in many wetlands in the Delta Region of Arkansas.

Flooding is also critical for the maintenance of many plant communities within the region, but this relationship is considered separately as a basic classification factor. As noted elsewhere, characterization of flood frequency and duration in the Delta Region of Arkansas is difficult, and cannot often be interpreted in a way that would add meaningfully to the assessment of plant community maintenance.

## **Function 7: Provide Habitat for Fish and Wildlife**

### **Definition and applicability**

This function is defined as the ability of a wetland to support the fish and wildlife species that utilize wetlands during some part of their life cycles. Potential independent, quantitative measures of this function are animal inventory approaches, with data analysis usually employing comparisons between sites using a similarity index calculated from species composition and abundance (Odum 1950; Sorenson 1948).

This function is assessed in all six subclasses in the Delta Region of Arkansas.

### **Rationale for selecting the function**

Terrestrial, semiaquatic, and aquatic animals use wetlands extensively. Maintenance of this function ensures habitat for a diversity of vertebrate organisms, contributes to secondary production, and maintains complex trophic interactions. Habitat functions span a range of temporal and spatial scales, and include the provision of refugia and habitat for wide-ranging or migratory animals as well as highly specialized habitats for endemic species. However, most wildlife and fish species found in wetlands of the Delta Region of Arkansas depend on certain aspects of wetland structure and dynamics, such as periodic flooding or ponding of water, specific vegetation composition, and proximity to other habitats.

### **Characteristics and processes that influence the function**

The quality and availability of habitats for fish and wildlife species in wetlands of the Delta Region of Arkansas are dependent on a variety of factors operating at different scales. Habitat components that can be considered in a rapid field assessment include vegetation structure and composition; detrital elements; availability of water, both from precipitation and flooding; and spatial attributes such as patch size and connectivity.

Forested wetlands typically are floristically and hydrologically complex (Wharton et al. 1982). Structural diversity in the vertical plane generally increases with vegetation maturity (Hunter 1990). Vegetation diversity on the horizontal plane derives from gap-phase regeneration dynamics and the complex patterns of alluvial deposition that produce interspersed low ridges, swales,

abandoned channel segments, and other features that differentially flood or pond rainwater, and support distinctively different plant communities (see Chapter 3). This structural diversity provides myriad habitat conditions for animals and allows numerous species to coexist in the same area (Schoener 1986). The compositional diversity typical of lowland forests also assures the availability of a wide variety of food resources (Allen 1987).

Detrital components of the ecosystem are of considerable significance to animal populations in lowland hardwood wetlands. Litter provides ideal habitat for small animals such as salamanders (Johnson 1987), and has a distinctive invertebrate fauna (Wharton et al. 1982) that is vital to some of the more visible members of the community. For example, prior to laying eggs, wood ducks forage extensively on macroinvertebrates found in the floodplain. Similarly, mallards heavily utilize the abundant litter invertebrate populations associated with flooded or ponded bottomland forests during winter (Batema et al. 1985). Logs and other woody debris provide cover and a moist environment for many species including invertebrates, small mammals, reptiles, and amphibians (Hunter 1990). Animals found in forested wetlands use logs as resting sites, cover, feeding platforms, and as sources of food (Harmon et al. 1986; Loeb 1993). Standing dead trees (snags) are used by numerous bird species, and several species are dependent on snags for their existence (Scott et al. 1977). Stauffer and Best (1980) found that most cavity-nesting birds, particularly the primary cavity nesters such as woodpeckers, preferred snags versus live trees. Mammals such as bats, squirrels, and raccoons also are dependent on snags to varying extents (Howard and Allen 1989), and most species of forest-dwelling mammals, reptiles, and amphibians, along with numerous invertebrates, seek shelter in cavities, at least occasionally (Hunter 1990).

In wetlands of the Delta Region of Arkansas, hydrology is one of the major factors influencing wildlife habitat quality. A significant hydrologic component is precipitation, particularly where it is captured in vernal pools and small puddles. These sites are a source of surface water for various terrestrial animals, and provide reproductive habitat for invertebrates and amphibians, many of which are utilized as a food source by other animals (Johnson 1987; Wharton et al. 1982). Ponded breeding sites without predatory fish populations are very important for some species of salamanders and frogs (Johnson 1987).

While temporary ponding of precipitation is important to many species precisely because it provides an aquatic environment that is isolated from many aquatic predators, wetlands that are periodically river-connected also provide vital habitat for some species. Wharton et al. (1982), who provided an overview of fish use of bottomland hardwoods in the Piedmont and eastern Coastal Plain, stated that at least 20 families and up to 53 species of fish use various portions of the floodplain for foraging and spawning. Baker and Killgore (1994) reported similar results from the Cache River drainage in Arkansas, where they found that most fish species exploit floodplain habitats at some time during the year, many for spawning and rearing. In addition to flooding itself, the complex environments of floodplains are of significance to fish. Wharton et al. (1982) listed numerous examples of fish species being associated with certain portions of the floodplain. Baker et al. (1991) noted that the different microhabitats on the floodplain typically supported different fish assemblages from those of the



channel. Baker and Killgore (1994) stated that "the structurally complex environment of irregularly flooded oak-hickory forests provide optimum habitat for many wetland fish."

Just as topographic variations provide essential wetland habitats such as isolated temporary ponds and river-connected backwaters, they also provide sites that generally remain dry. Such sites are important to ground-dwelling species that cannot tolerate prolonged inundation. Wharton et al. (1982) stated that old, natural levee ridges are extremely important to many floodplain species, because they provide winter hibernacula and refuge areas during periods of high water. Similarly, Tinkle (1959) found that natural levees were used extensively as egg-laying areas by many species of reptiles and amphibians.

Landscape-level features such as forest patch size, shape, connectivity, and surrounding land use are also important attributes that affect the lowland wildlife community (Hunter 1990; Morrison et al. 1992). It is generally assumed that reduction and fragmentation of forest habitat, coupled with changes in the remaining habitat, resulted in the loss of the ivory-billed woodpecker, Bachman's warbler, and the red wolf (*Canis rufus*), as well as severe declines in the black bear and Florida panther (*Puma concolor coryi*). The extent to which patch size affects animal populations has been most thoroughly investigated with respect to birds, but the results have been inconsistent (Askins et al. 1987; Blake and Karr 1984; Howe 1984; Keller et al. 1993; Kilgo et al. 1997; Lynch and Whigham 1984; Sallabanks et al. 1998; Stauffer and Best 1980). However, the negative effects of forest fragmentation on some species of birds have been well documented (Finch 1991). These species, referred to as forest interior species, apparently respond negatively to unfavorable environmental conditions or biotic interactions that occur in fragmented forests (Ambuel and Temple 1983). The point at which forest fragmentation affects different bird species has yet to be defined, and study results have been inconsistent (e.g., Temple 1986; Wakeley and Roberts 1996). Thus, the area needed to accommodate all the species typically associated with large patches of forested wetlands in the region can only be approximated. One such approximation (Mueller et al. 1995) identified three groups of birds that breed in the Mississippi Alluvial Valley with (presumably) similar needs relative to patch size. That study suggested that, to sustain source breeding populations of individual species within the three groups, 44 patches of 4,000 – 8,000 ha, 18 patches of 8,000 – 40,000 ha, and 12 patches larger than 40,000 ha are needed. Species such as Swainson's warbler (*Limnothlypis swainsonii*) are in the first group; more sensitive species such as the cerulean warbler (*Dendroica cerulea*) are in the second group; and those with very large home ranges (e.g., raptors such as the red-shouldered hawk) (*Buteo lineatus*) are in the third group.

The land use surrounding a tract of forest also has a major effect on avian populations. Recent studies (Robinson et al. 1995; Sallabanks et al. 1998; Thompson et al. 1992; Welsh and Healy 1993) suggest that bird populations respond to fragmentation differently in forest-dominated landscapes than in those in which the bulk of the forests have been permanently lost to agriculture or urbanization. Generally, these studies indicate that as the mix of feeding habitats (agricultural and suburban lands) and breeding habitats (forests and grasslands) increases, predators and nest parasites become increasingly successful, even if

large blocks of habitat remain. Thus, in more open landscapes, block sizes need to be larger than in mostly forested ones. Conversely, Robinson (1996) estimated that as the percentage of the landscape that is forested increases above 70 percent (approximately), the size of the forest blocks within that landscape becomes less significant to bird populations.

In landscapes that are fragmented, corridors have been suggested as a means of ameliorating many of the anticipated negative effects of fragmentation (Harris 1985; Noss and Harris 1986), although there is disagreement over the benefits of corridors (Simberloff et al. 1992). In bottomland forest communities, probably the most significant habitat connection for many species is between floodprone areas and nonflooded habitats of similar structure, which allows terrestrial species to seek refuge during periods of high water (Wharton et al. 1982). In general, connections between different wetland types, and between uplands and wetlands, help maintain higher animal and plant diversity across the landscape than if habitats are more isolated from one another (Sedell et al. 1990).

### General form of the assessment model

The model for assessing the Provide Habitat for Fish and Wildlife function includes the following assessment variables, which are discussed in greater detail in Chapter 6:

$V_{FREQ}$	= frequency of flooding
$V_{POND}$	= microdepressional ponding
$V_{TCOMP}$	= tree composition
$V_{SNAG}$	= snag density
$V_{STRATA}$	= number of vegetation layers
$V_{TBA}$	= tree basal area
$V_{LOG}$	= log density
$V_{OHOR}$	= O horizon thickness
$V_{TRACT}$	= wetland tract size
$V_{CONNECT}$	= habitat connections
$V_{CORE}$	= core area

The model can be expressed in a general form:

$$FCI = \left\{ \left[ \frac{(V_{FREQ} + V_{POND})}{2} \right] \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \right\}^{1/4} \times \left\{ \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right] \right\} \quad (7)$$

The expressions within the model reflect the major habitat components described previously. The first expression concerns hydrology, and includes indicators of both extensive seasonal inundation and river access by aquatic organisms ( $V_{FREQ}$ ) as well as the periodic occurrence of temporary, isolated aquatic conditions ( $V_{POND}$ ). The second expression includes indicators of forest structure and diversity, specifically overstory basal area ( $V_{TBA}$ ), overstory tree species composition ( $V_{TCOMP}$ ), structural complexity ( $V_{STRATA}$ ), and snag density ( $V_{SNAG}$ ). Habitat structure for animals associated with detrital components is indicated by two variables: the volume of logs per unit area ( $V_{LOG}$ ) and the thickness of the O horizon ( $V_{OHOR}$ ). Note that the litter layer, which is important to some species, is not included in the model due to its seasonality – instead, the O horizon is used as an indicator of litter accumulation, since it is a direct result of litter decay. Three landscape-level variables are incorporated within the model to reflect the importance of habitat fragmentation and interhabitat continuity as considerations in determining habitat quality for a large percentage of wildlife species within the Delta Region of Arkansas: the size of the overall wetland complex independent of the boundaries of the assessment area ( $V_{TRACT}$ ); the proportion of the assessment area that is buffered from surrounding land uses and edge effects ( $V_{CORE}$ ); and the proportion of the assessment area boundary that is connected to other suitable habitat types via appropriate movement corridors ( $V_{CONNECT}$ ).

## 5 Model Applicability and Reference Data

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The assessment models described in Chapter 4 are applied to individual wetland subclasses in different ways. This is because not all of the assessment models and variables are applicable to all of the regional wetland subclasses. For example, the Export Organic Carbon function is applicable only to the Low-Gradient Riverine Overbank and Backwater, Headwater Depression, and Connected Depression subclasses, and is not assessed in subclasses having no export mechanism (flooding) (i.e., Isolated Depressions and Flats). Similarly, some variables can be deleted from assessment models for subclasses where they cannot be consistently evaluated. For example, ground vegetation cover  $V_{GVC}$ , litter cover  $V_{LITTER}$ , woody debris and logs  $V_{WD}$  and  $V_{LOG}$ , and thickness of the O and A horizons  $V_{OHOR}$  and  $V_{AHOR}$  may be difficult to assess in depressions that are inundated, and modified versions of the models applicable to the depression subclasses are provided for use in those situations. The modified models are likely to be less sensitive than the full versions, but they are complete enough to be used when necessary.

Assessment models also differ among subclasses with regard to their associated reference data. Each subclass was the focus of detailed sampling during development of this guidebook, and the reference data collected for each subclass have been independently summarized for application. The following sections present information for each wetland subclass with regard to model applicability and reference data. For each subclass, each of the seven potential functions available for assessment is listed, and the applicability of the assessment model is described. The model is presented as described in Chapter 4 if it is applicable in its general and complete form; it is presented in a modified form if certain variables cannot be consistently assessed in certain subclasses; and the function is identified as "Not Assessed" in cases where the wetland subclass does not perform the function as described in Chapter 4, or where it cannot be assessed with the methods and model available for rapid field assessment. For each wetland subclass, functional capacity subindex curves are presented for every assessment variable used in the applicable assessment models, based on reference data.

### Subclass: Flat

Four functions are assessed for this subclass. Most of the applicable assessment models have not been changed from the general model form presented in

Chapter 4. Figure 16 provides the relationship between the variable metrics and the subindex for each of the assessment models based on the reference data. Note that, unlike other subclasses, the Flat subclass subindex curves for percent ponding reflect three different geomorphic settings, and it is necessary to identify the setting when assembling field data. Specific guidance is provided on the field data forms for Non-Alkali Flat Wetlands in Appendix B.

- a. *Function 1: Detain Floodwater.* Not Assessed
- b. *Function 2: Detain Precipitation.*

$$FCI = \frac{\left[ V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2} \right]}{2}$$

- c. *Function 3: Cycle Nutrients.*

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

- d. *Function 4: Export Organic Carbon.* Not assessed.
- e. *Function 5: Remove Elements and Compounds.* Not assessed.
- f. *Function 6: Maintain Plant Communities.*

$$FCI = \left( \left[ \frac{\left( \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right)}{2} \right] \times \left[ \frac{(V_{SOIL} + V_{POND})}{2} \right] \right)^{1/2}$$

- g. *Function 7: Provide Wildlife Habitat.* Applicable in the following modified format:

$$FCI = \left\{ V_{POND} \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \times \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \right\}^{1/4} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

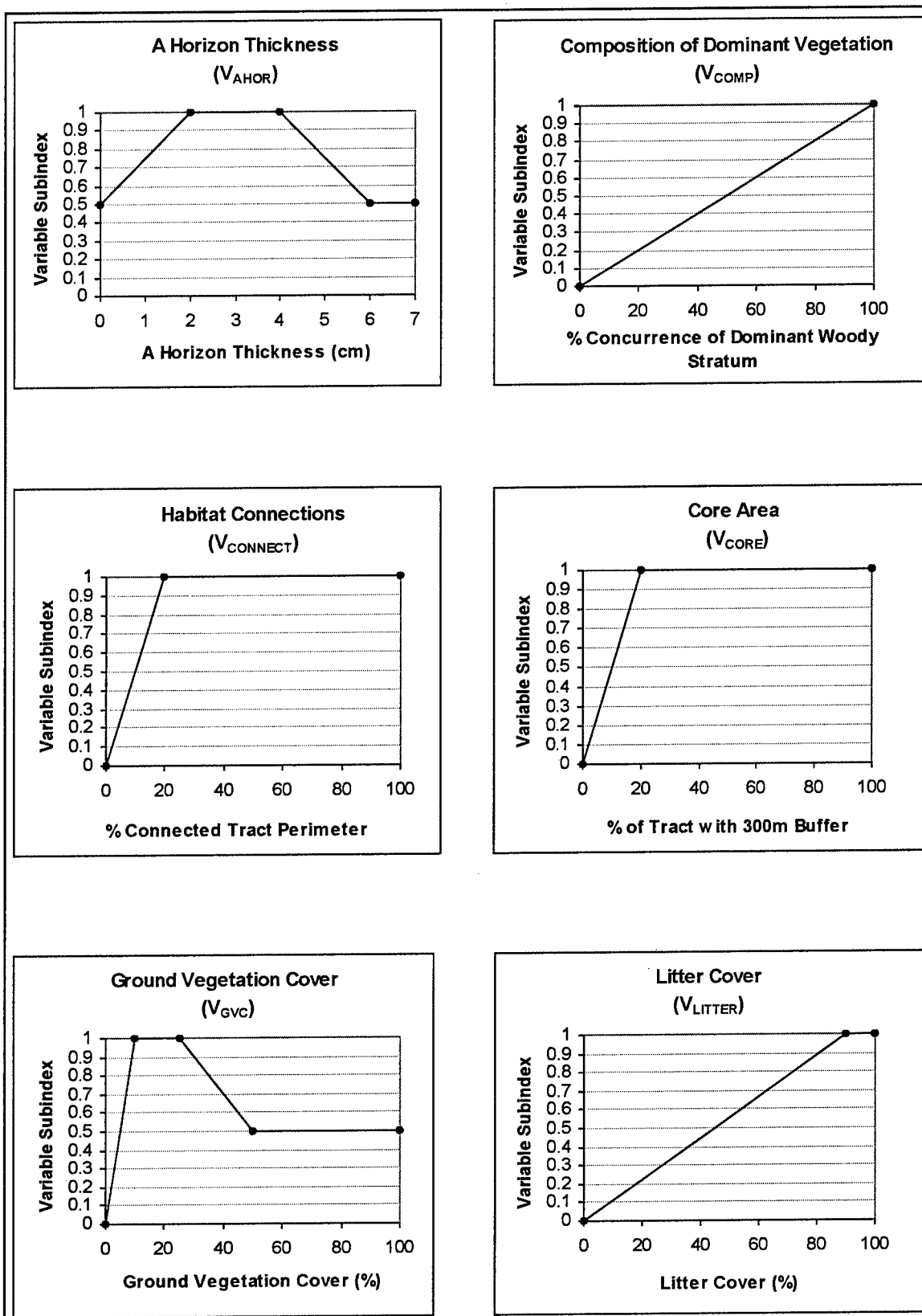


Figure 16. Subindex curves for Flat wetlands (Sheet 1 of 4)

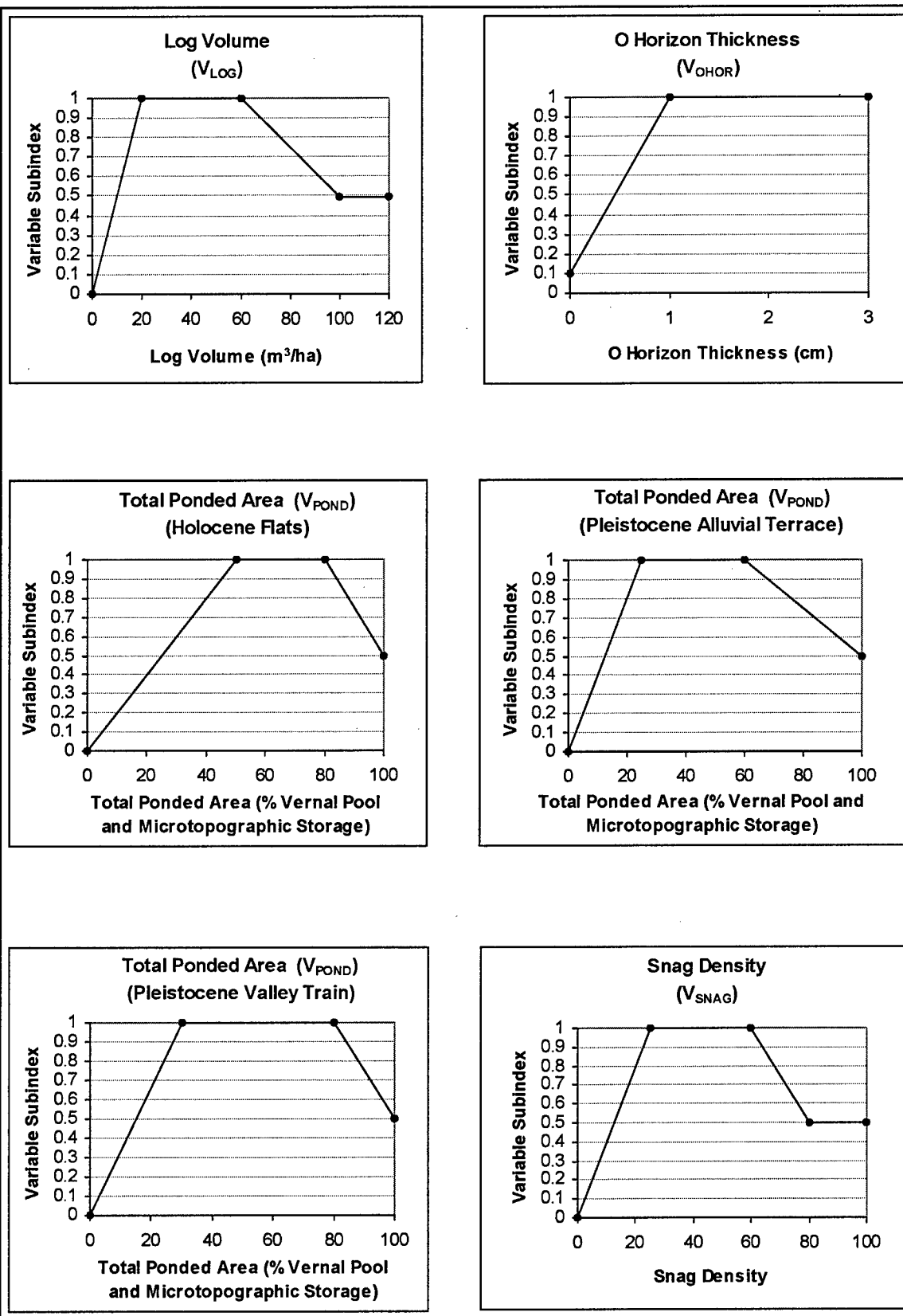


Figure 16. (Sheet 2 of 4)

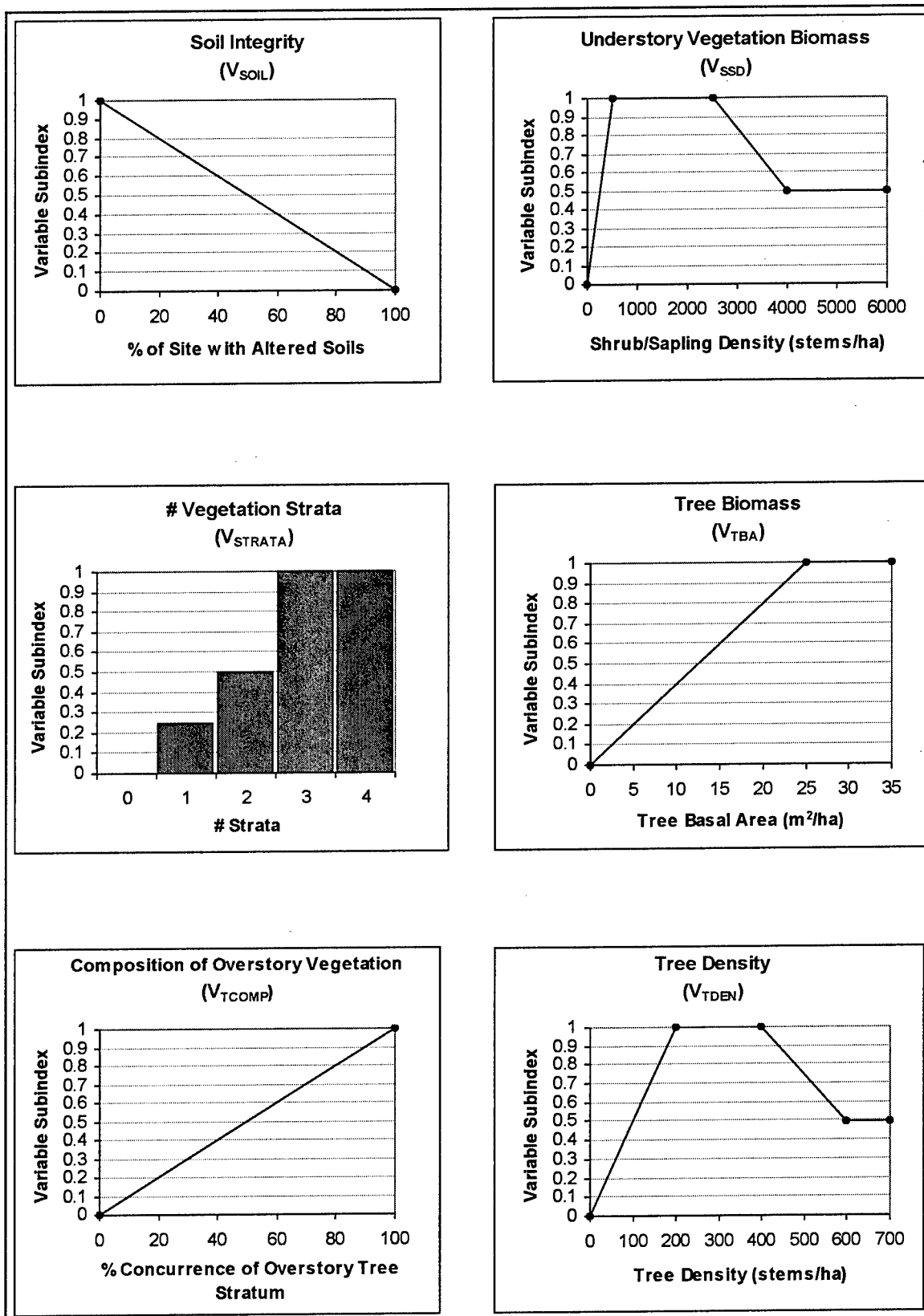


Figure 16. (Sheet 3 of 4)



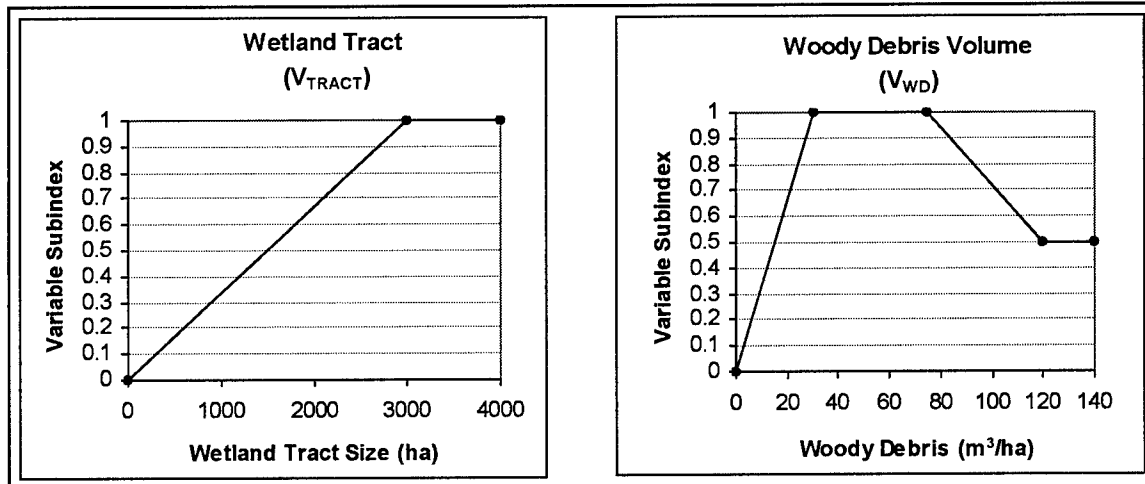


Figure 16. (Sheet 4 of 4)

## Subclass: Low-Gradient Riverine Backwater

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 17 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine backwater reference data.

a. *Function 1: Detain Floodwater.*

$$FCI = V_{REQ} \times \left[ \frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right]$$

b. *Function 2: Detain Precipitation.*

$$FCI = \frac{\left[ V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2} \right]}{2}$$

c. *Function 3: Cycle Nutrients.*

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

d. *Function 4: Export Organic Carbon.*

$$FCI = V_{REQ} \times \frac{\left[ \frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} \right] + \left[ \frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2}$$

e. *Function 5: Remove Elements and Compounds.*

$$FCI = V_{FREQ} \times \left[ \frac{(V_{CEC} + V_{OHOR} + V_{AHOR})}{3} \right]$$

f. *Function 6: Maintain Plant Communities.*

$$FCI = \left\{ \left[ \frac{\left( \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right)}{2} \right] \times \left[ \frac{(V_{SOIL} + V_{POND})}{2} \right] \right\}^{1/2}$$

g. *Function 7: Provide Wildlife Habitat.*

$$FCI = \left\{ \left[ \frac{(V_{FREQ} + V_{POND})}{2} \right] \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \right\}^{1/4} \times \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

## Subclass: Low-Gradient Riverine Overbank

All functions are assessed for this subclass using the general form of each assessment model presented in Chapter 4 as follows. Figure 18 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the riverine overbank reference data.

a. *Function 1: Detain Floodwater.*

$$FCI = V_{FREQ} \times \left[ \frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right]$$

b. *Function 2: Detain Precipitation.*

$$FCI = \frac{V_{POND} + \frac{(V_{OHOR} + V_{LITTER})}{2}}{2}$$

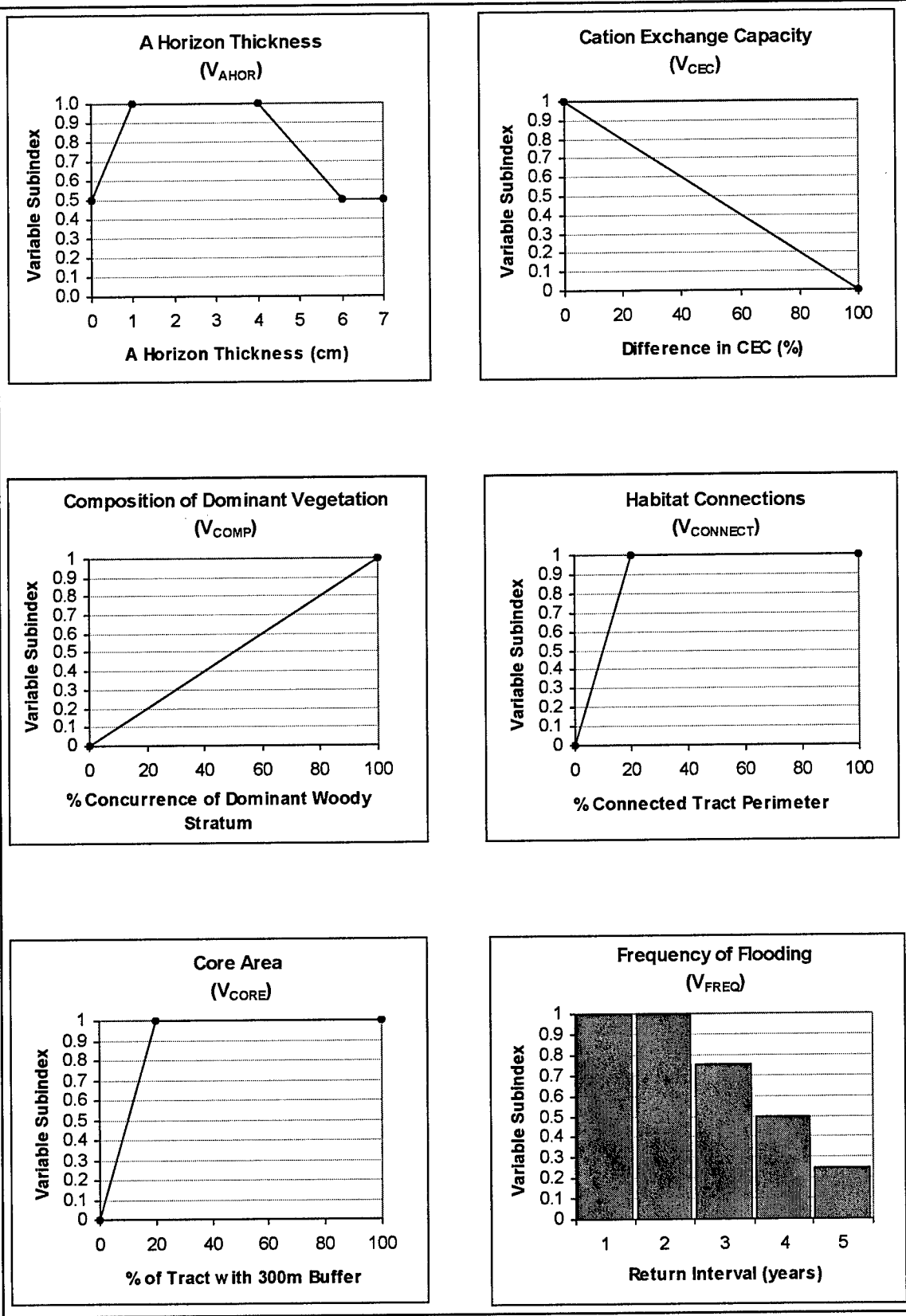


Figure 17. Subindex graphs for Low-Gradient Riverine Backwater wetlands (Sheet 1 of 4)

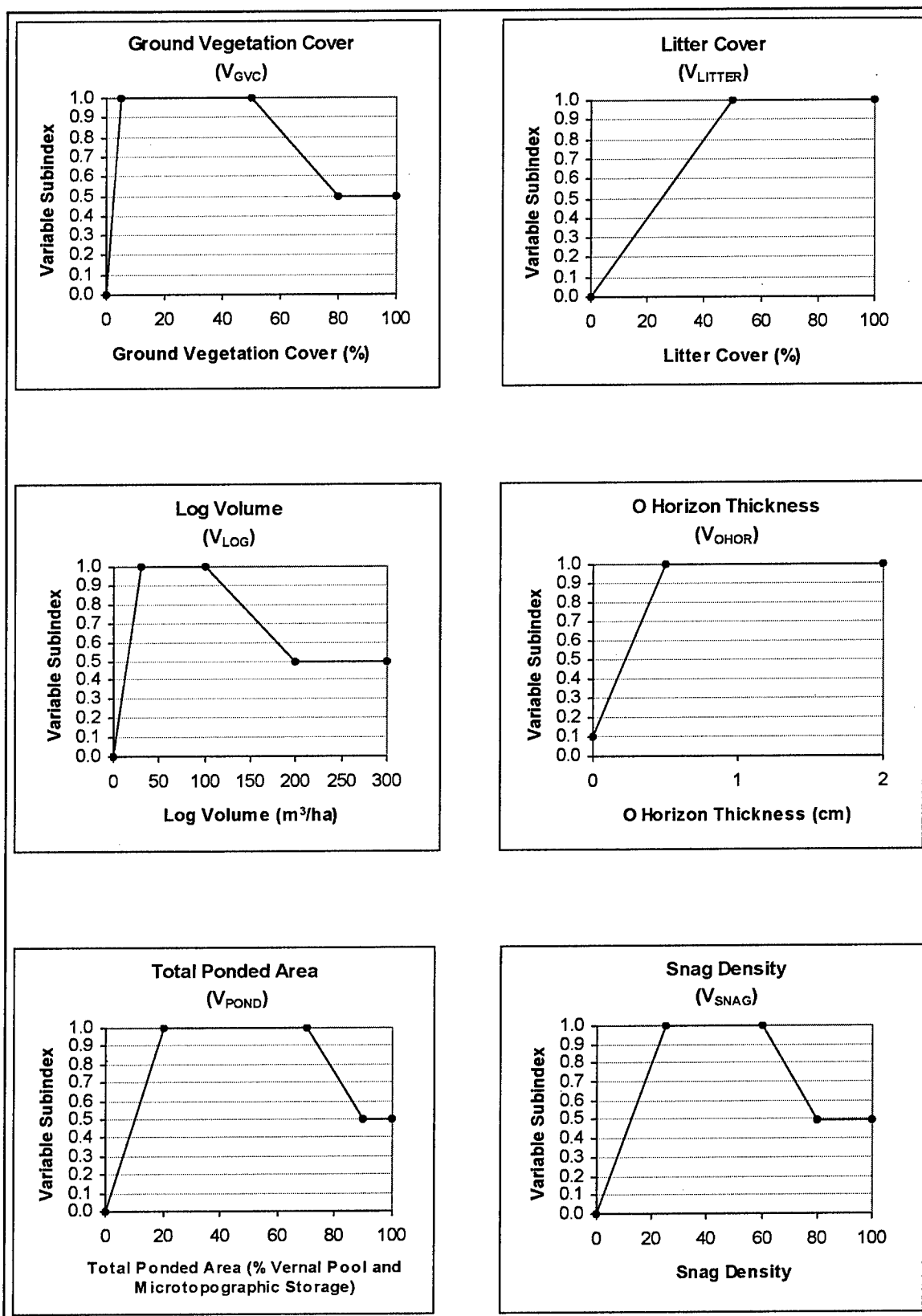


Figure 17. (Sheet 2 of 4)

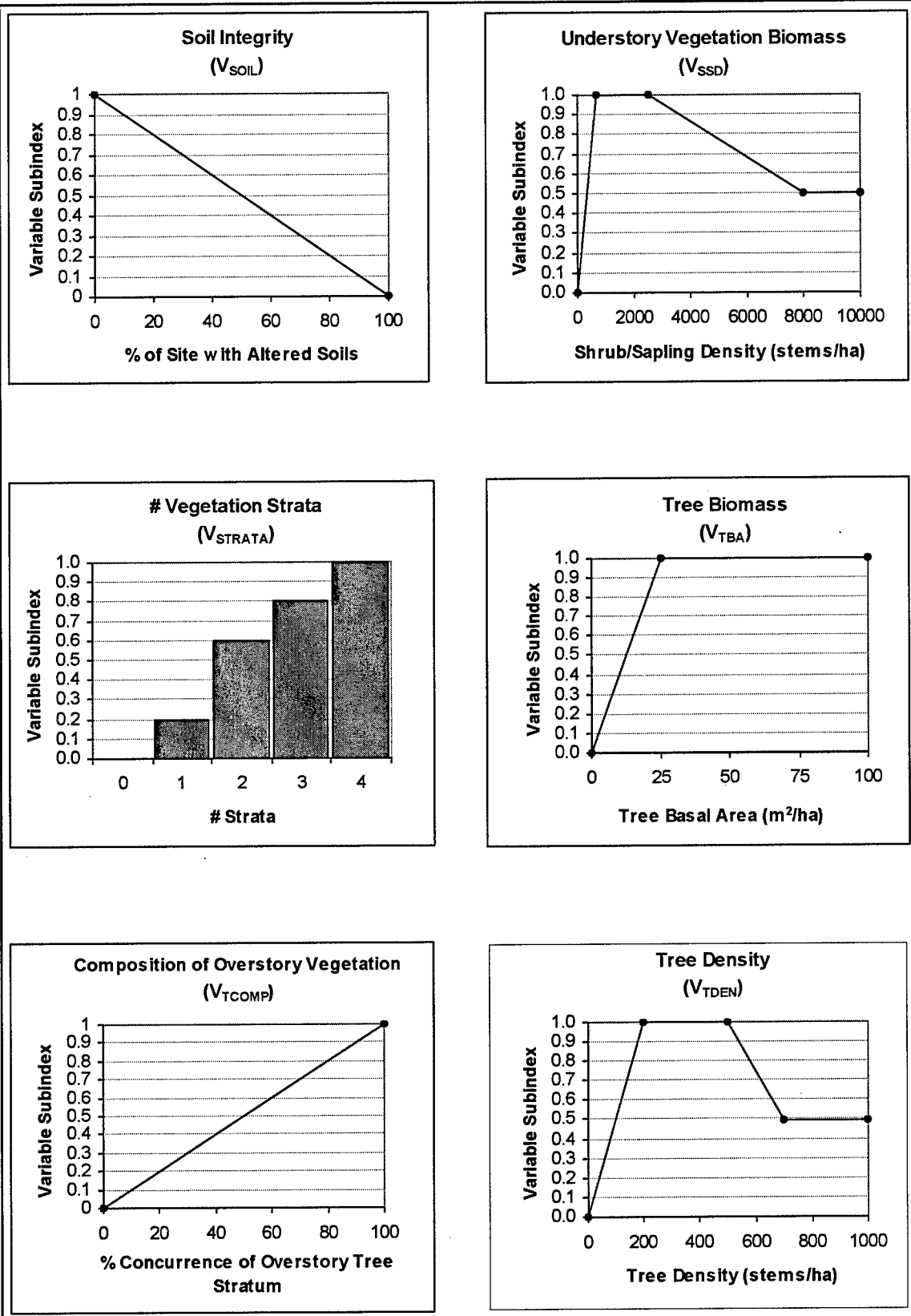


Figure 17. (Sheet 3 of 4)

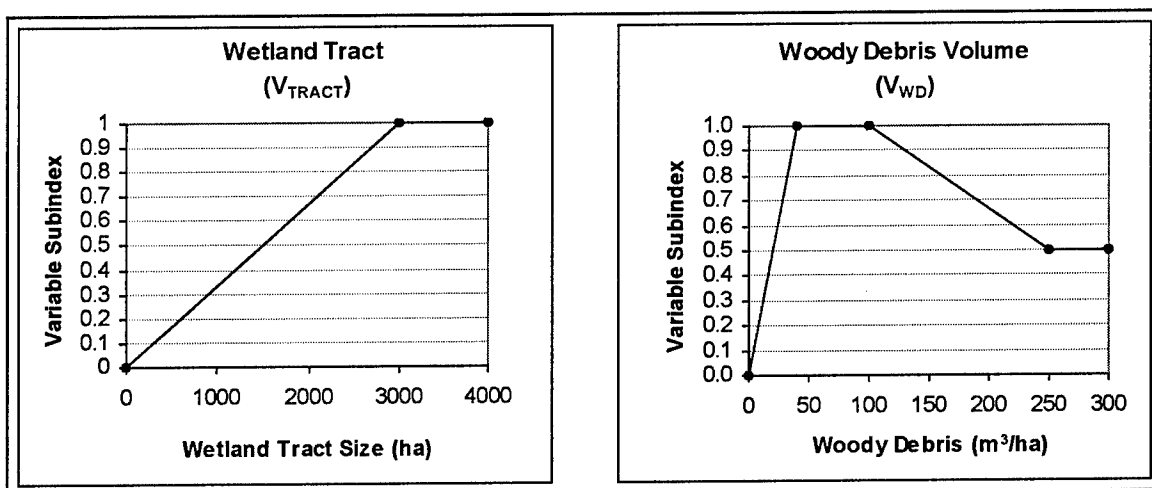


Figure 17. (Sheet 4 of 4)

c. *Function 3: Cycle Nutrients.*

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

d. *Function 4: Export Organic Carbon.*

$$FCI = V_{FREQ} \times \frac{\left[ \frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} \right] + \left[ \frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2}$$

e. *Function 5: Remove Elements and Compounds.*

$$FCI = V_{FREQ} \times \left[ \frac{(V_{CEC} + V_{OHOR} + V_{AHOR})}{3} \right]$$

f. *Function 6: Maintain Plant Communities.*

$$FCI = \left( \left[ \frac{\left( \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right)}{2} \right] \times \left[ \frac{(V_{SOIL} + V_{POND})}{2} \right] \right)^{1/2}$$

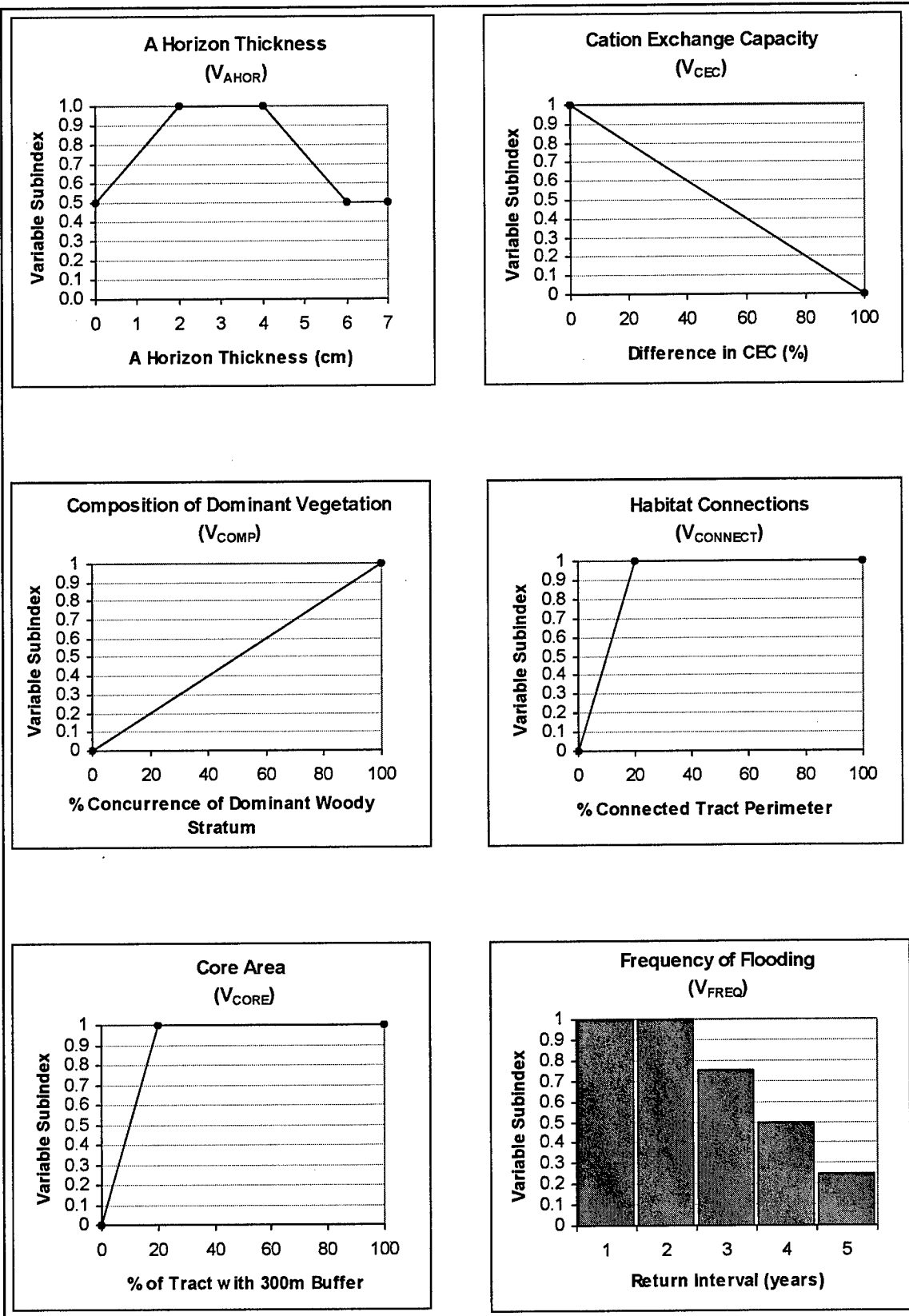


Figure 18. Subindex graphs for Low-Gradient Riverine Overbank wetlands (Sheet 1 of 4)

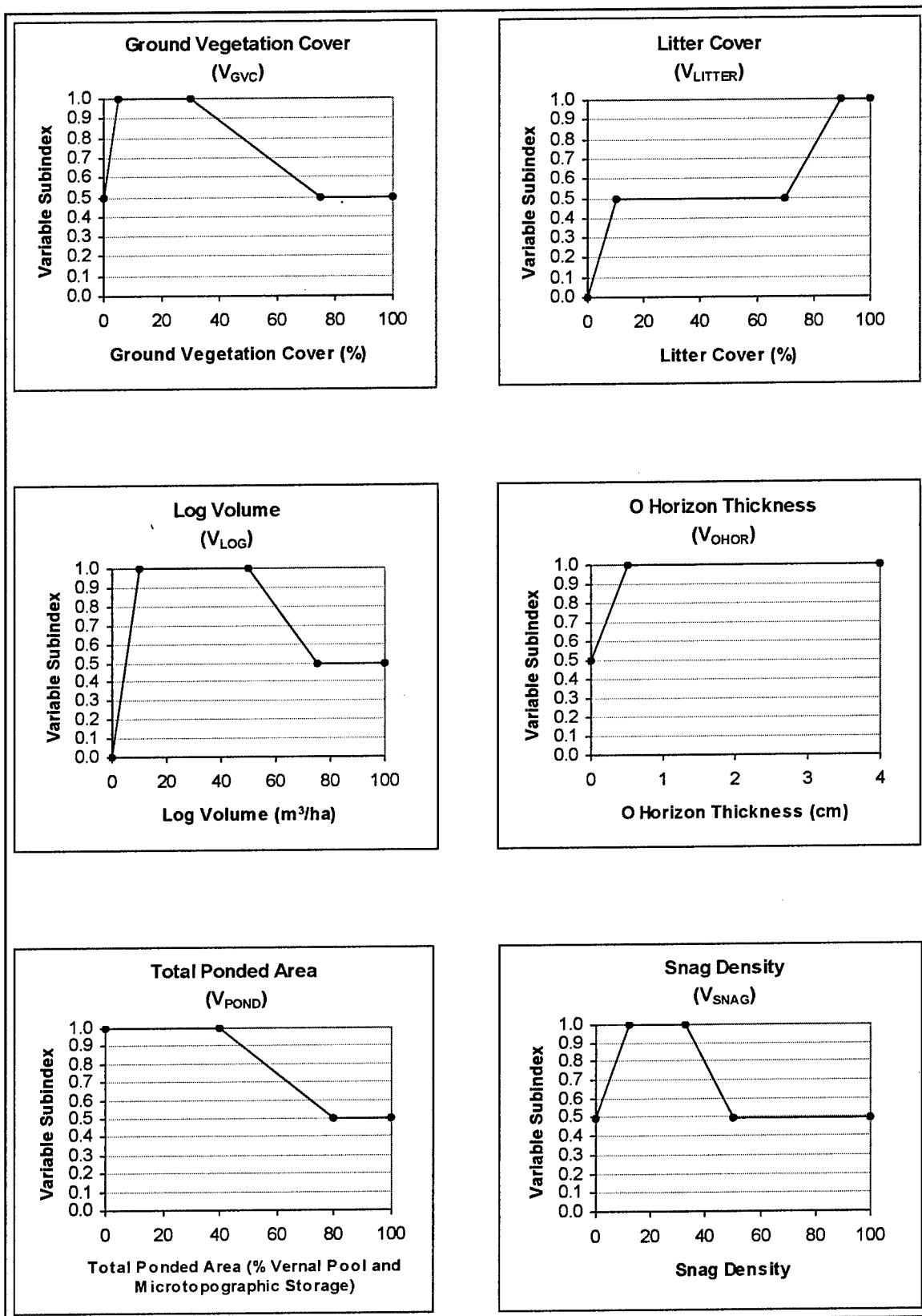


Figure 18. (Sheet 2 of 4)



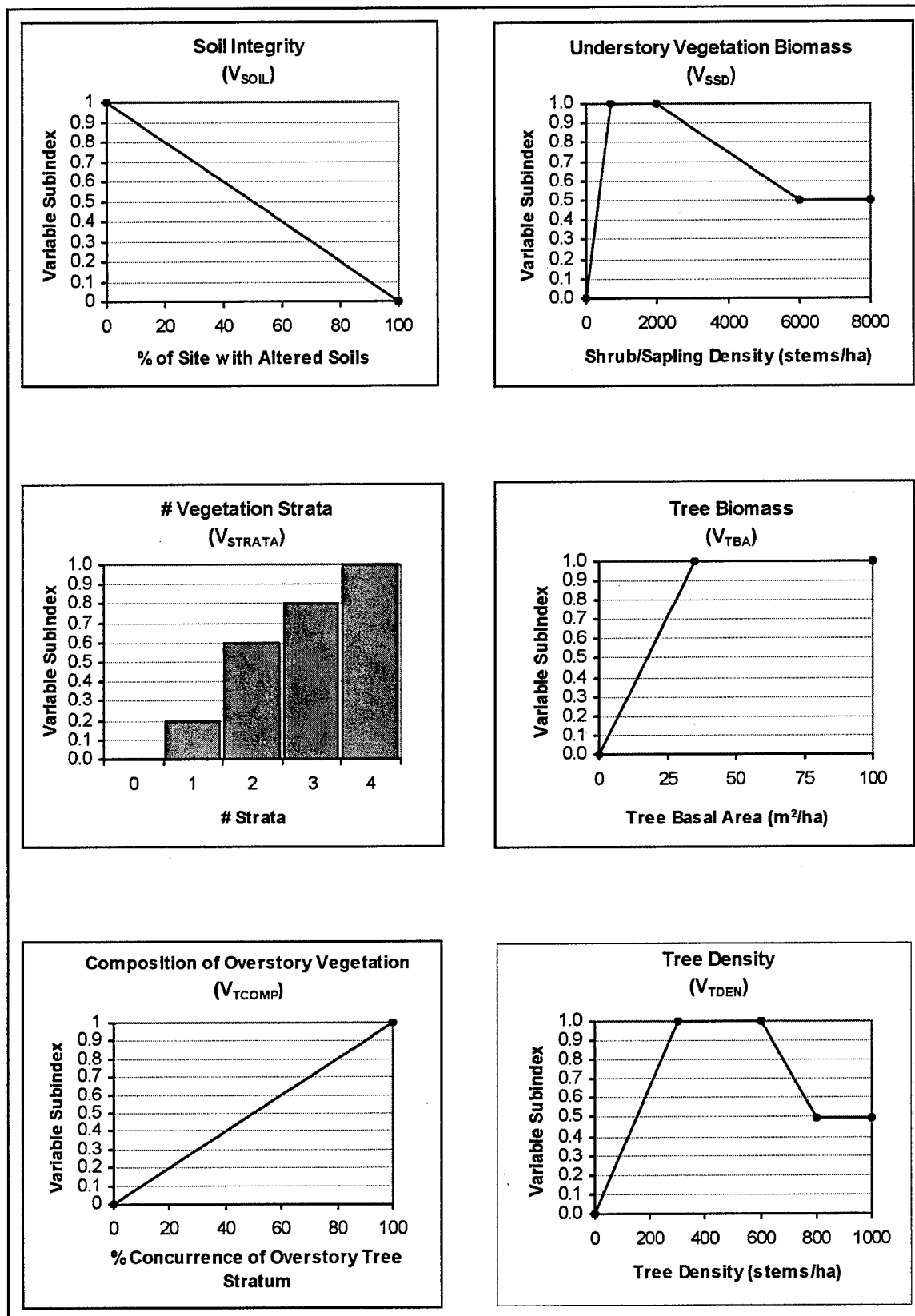


Figure 18. (Sheet 3 of 4)

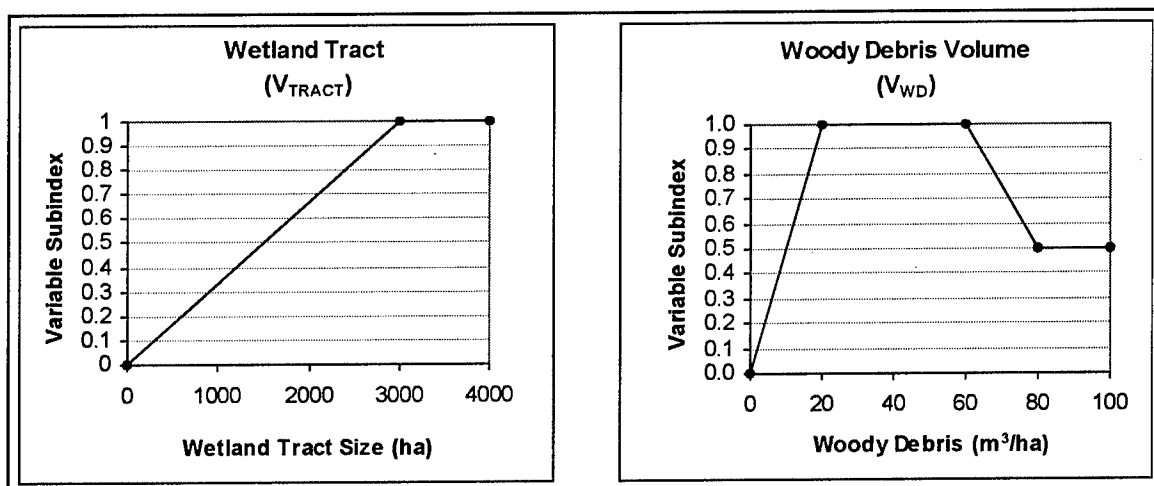


Figure 18. (Sheet 4 of 4)

g. *Function 7: Provide Wildlife Habitat.*

$$FCI = \left\{ \left[ \frac{(V_{FREQ} + V_{POND})}{2} \right] \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \right\}^{1/4} \times \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

## Subclass: Headwater Depression

Four functions are assessed for this subclass as shown in the following subparagraphs. All of the applicable models are modified from the general form presented in Chapter 4. In addition, alternate models are provided, which can be used in the event that ground-level observations cannot be made due to inundation. Figure 19 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the Headwater Depression reference data.

- a. *Function 1: Detain Floodwater.* Not Assessed.
- b. *Function 2: Detain Precipitation.* Not Assessed.
- c. *Function 3: Cycle Nutrients.*

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

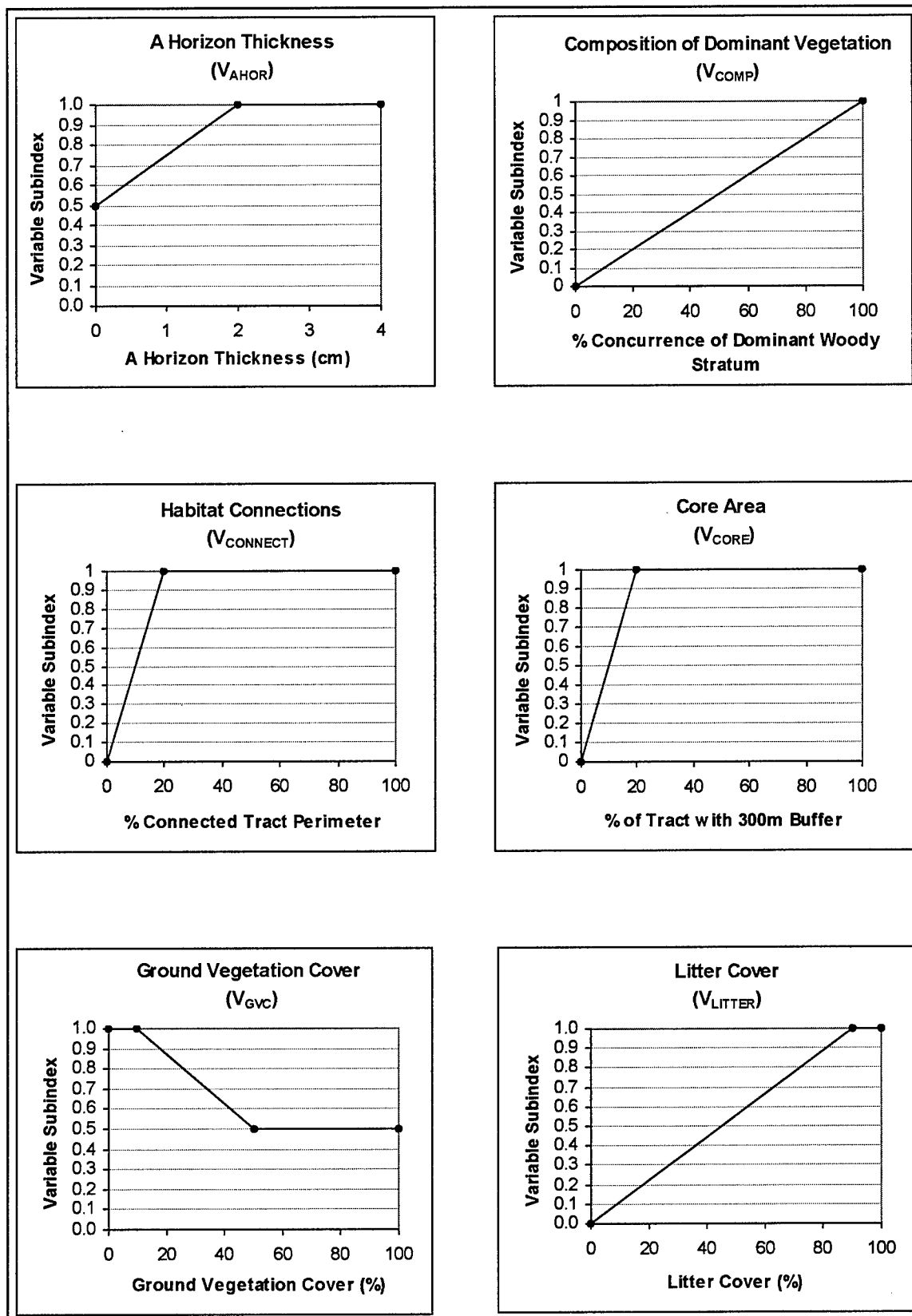


Figure 19. Subindex graphs for Headwater Depression wetlands (Sheet 1 of 3)

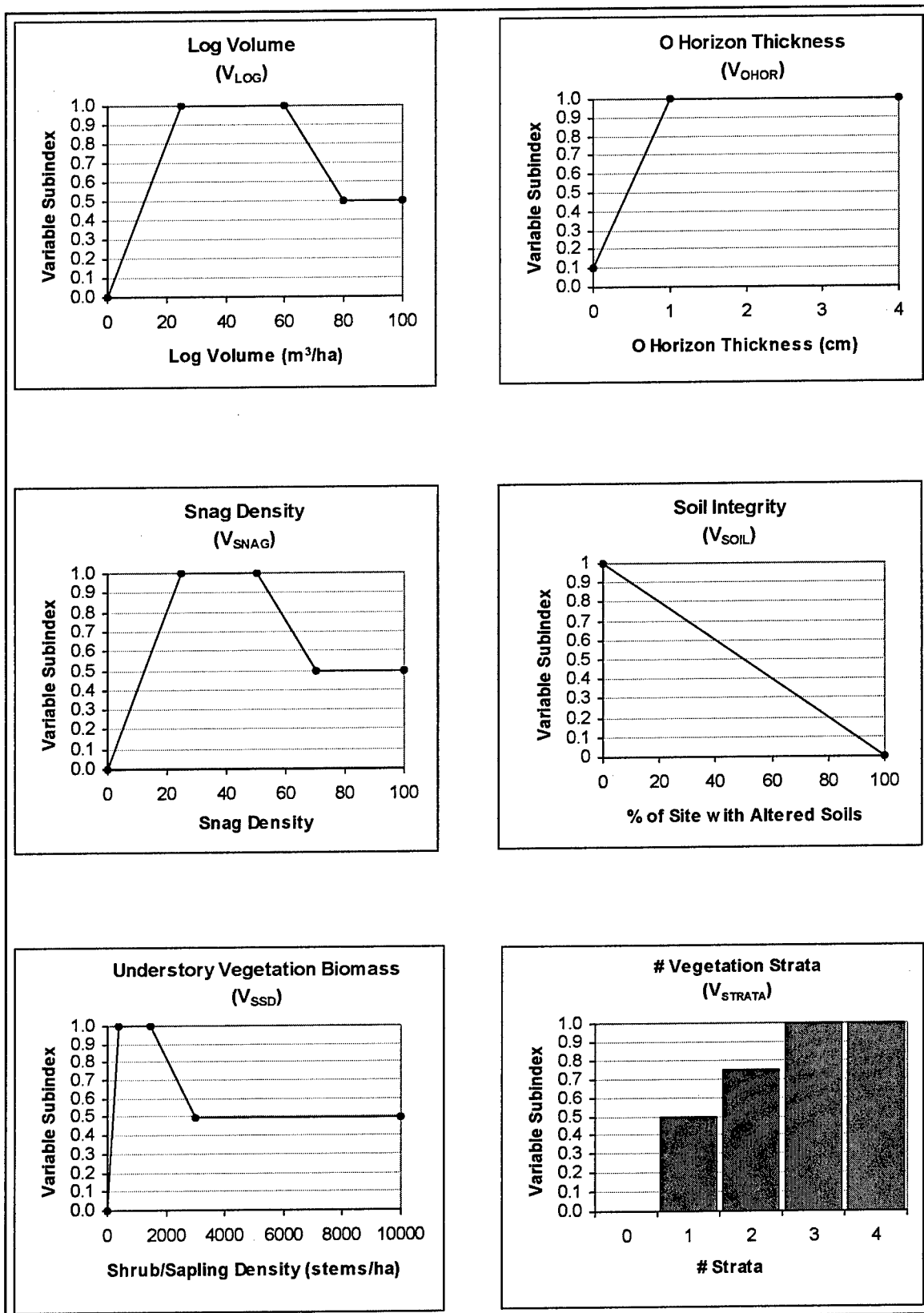


Figure 19. (Sheet 2 of 3)

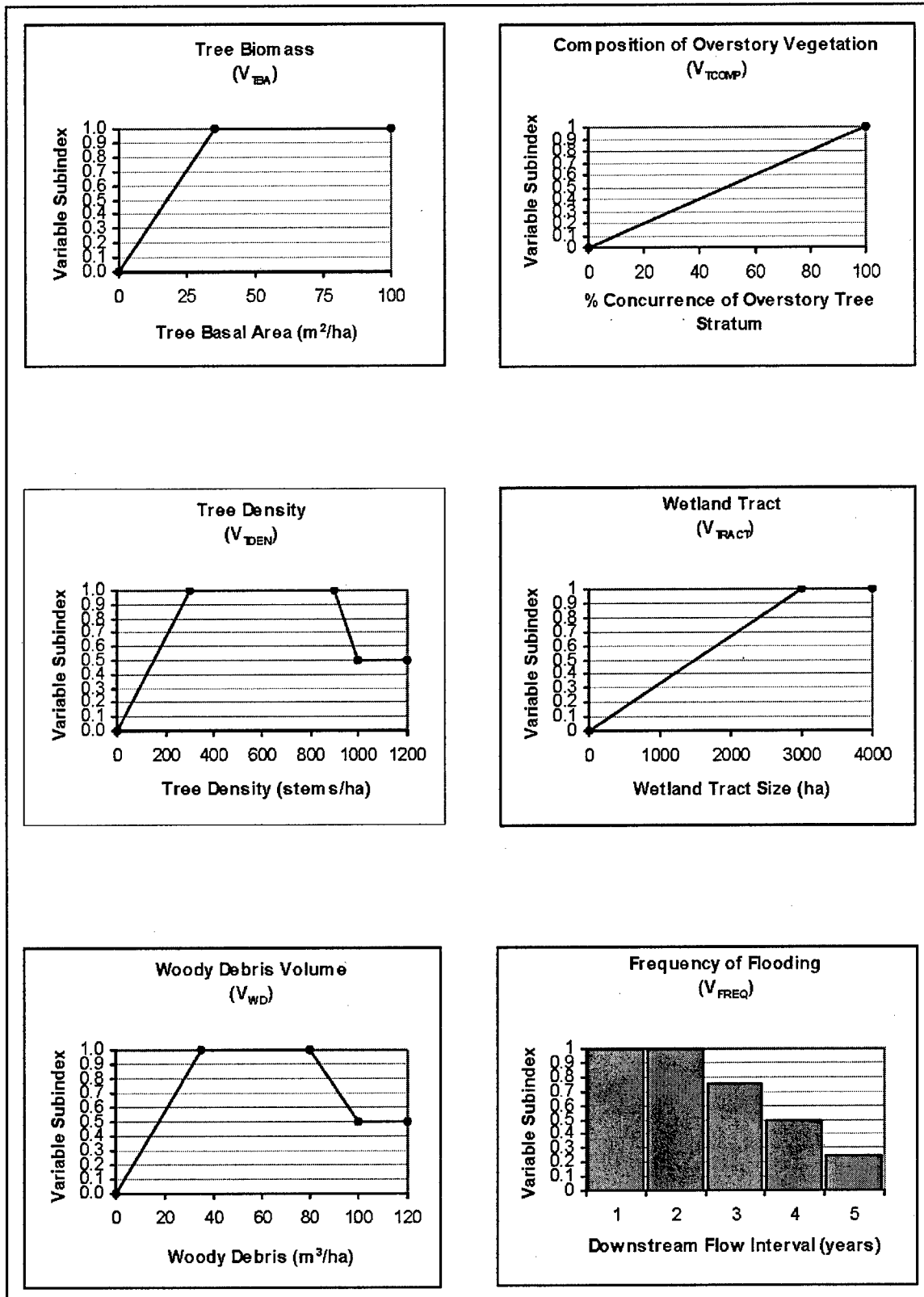


Figure 19. (Sheet 3 of 3)

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3}$$

d. *Function 4: Export Organic Carbon.*

$$FCI = V_{FREQ} \times \frac{\left[ \frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{4} \right] + \left[ \frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = V_{FREQ} \times \left[ \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3} \right]$$

e. *Function 5: Remove Elements and Compounds.* Not assessed.

f. *Function 6: Maintain Plant Communities.* Applicable in the following modified form:

$$FCI = \left( \left[ \frac{\left( \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right)}{2} \right] \times V_{SOIL} \right)^{1/2}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right]}{2}$$

g. *Function 7: Provide Wildlife Habitat.* Applicable in the following modified form:

$$FCI = \left\{ \left[ \frac{(V_{TCCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \times \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \right\}^{1/3} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \left\{ \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right]^{1/2} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right] \right\}$$

Note that Headwater Depressions differ from other wetland types in that the assessment procedure does not include consideration of flood frequency in most of the models where it is normally applicable. Headwater Depressions are to be considered flooded in any year that they accumulate enough water to result in downstream channel flows. In fact, this appears to be the case in most years in all of the reference sites. However, the Detain Floodwater variable is not assessed for this subclass, because that function as defined refers specifically to capture of out-of-bank stream floodwaters. Because the Headwater Depression type evidently is groundwater-maintained, water is unlikely to be delivered to the system with the sudden hydrograph peak observed on stream systems; thus the contribution to floodwater detention is more similar to non-flooded systems and is not assessed here.

The flood frequency estimate is used in the carbon export model, because organic material produced within the wetland is likely to move downstream with the outflow. Headwater depressions that produce downstream flows every year or every other year are considered to have adequate "flood frequency" to fully support the carbon export function. Headwater depressions that produce downstream flows less than one year in five are not considered to export carbon in significant amounts (i.e., they have a  $V_{FREQ}$  of zero) (Figure 19).

Flood frequency is not used as a variable in the model for the function "Remove Elements and Compounds," which was previously defined as referring to removal of dissolved materials from the water column, and specifically referred to water arriving from stream flooding. While Headwater Depressions certainly remove materials from their floodwaters, those waters appear to be of groundwater origin. Given the lack of information about the range or types of materials in those groundwaters, this function is not assessed for the Headwater Depression subclass.

Similarly, flood frequency is not used as a variable in the wildlife habitat model, where it normally is intended to indicate primarily waterfowl and fish habitat availability. This is because flood timing may differ significantly from other wetland types, and because it is unlikely that these systems have fisheries functions similar to those of the Connected Depression or Low-Gradient Riverine subclasses. Unlike those river-inundated systems, Headwater Depression wetlands are not periodically overwhelmed by floodwaters, but are connected to downstream systems by small and usually intermittent channels. Although fish may or may not access these sites on a regular basis, too little is known about

such use to support inclusion of this variable in the assessment process for habitat functions.

For all of the depressional subclasses, the “percent ponding” variable is excluded from the models. Ponding (microdepressional storage) is difficult to estimate within an overall depressional system, as these systems generally drain to a central low point, then fill and overwhelm individual pond sites. The functional contribution of the micro-sites to precipitation storage, wildlife habitat, and similar functions is not evident in a system where a single, large pool is the dominant hydrologic feature.

## Subclass: Isolated Depression

Three functions are assessed for this subclass as follows. Some of the applicable models are modified from the general form presented in Chapter 4. Alternate versions also are provided that can be used in the event that ground-level observations cannot be made due to inundation. Figure 20 provides the relationship between the variable metrics and the subindex for each of the assessment variables based on the isolated depression reference data.

- a. *Function 1: Detain Floodwater.* Not assessed.
- b. *Function 2: Detain Precipitation.* Not assessed.
- c. *Function 3: Cycle Nutrients.*

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3}$$

- d. *Function 4: Export Organic Carbon.* Not assessed.
- e. *Function 5: Remove Elements and Compounds.* Not assessed.
- f. *Function 6: Maintain Plant Communities.* Applicable in the following modified form:

$$FCI = \left( \left[ \frac{\left( \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right)}{2} \right] \times V_{SOIL} \right)^{1/2}$$



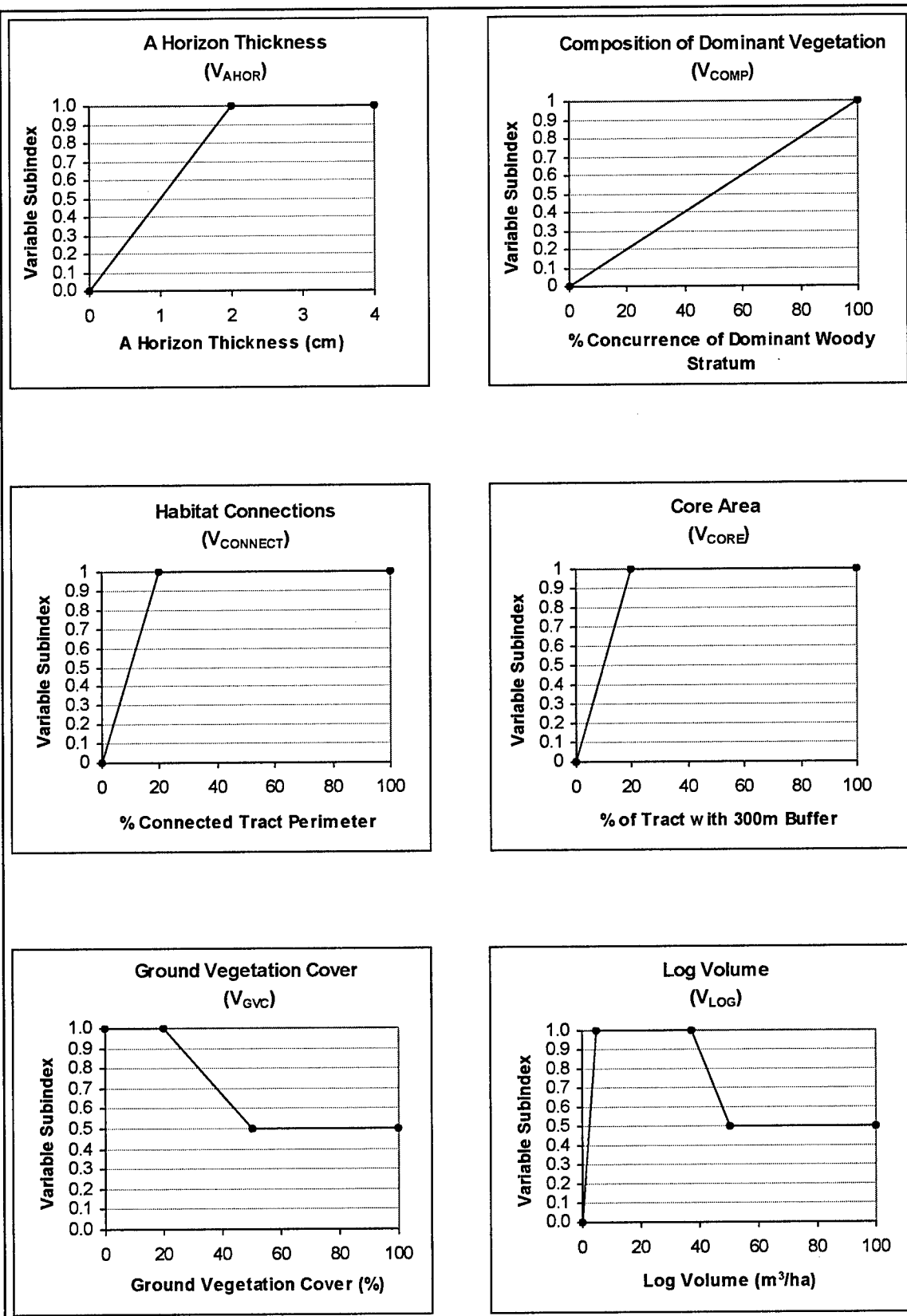


Figure 20. Subindex graphs for Isolated Depression wetlands (Sheet 1 of 3)

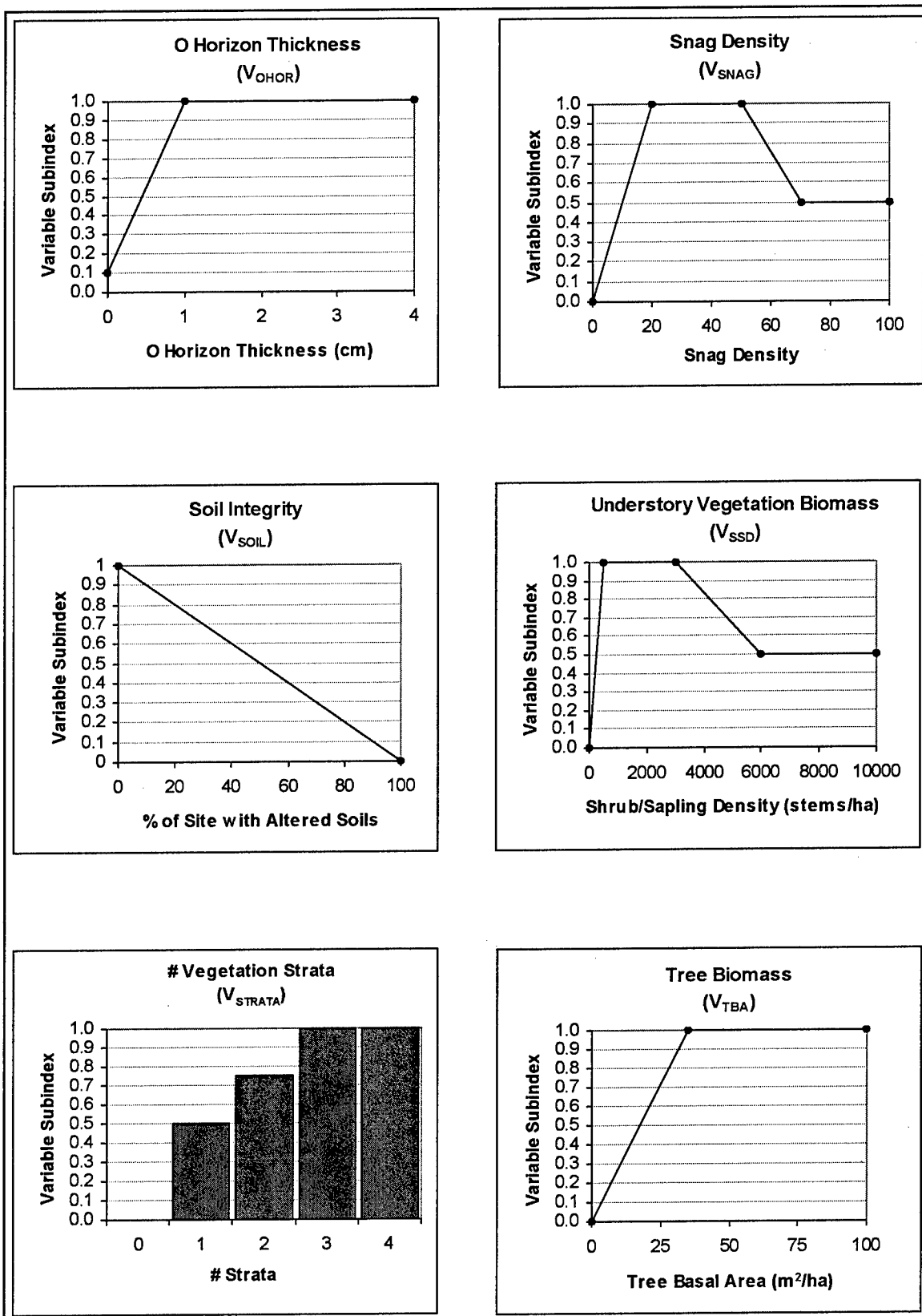


Figure 20. (Sheet 2 of 3)

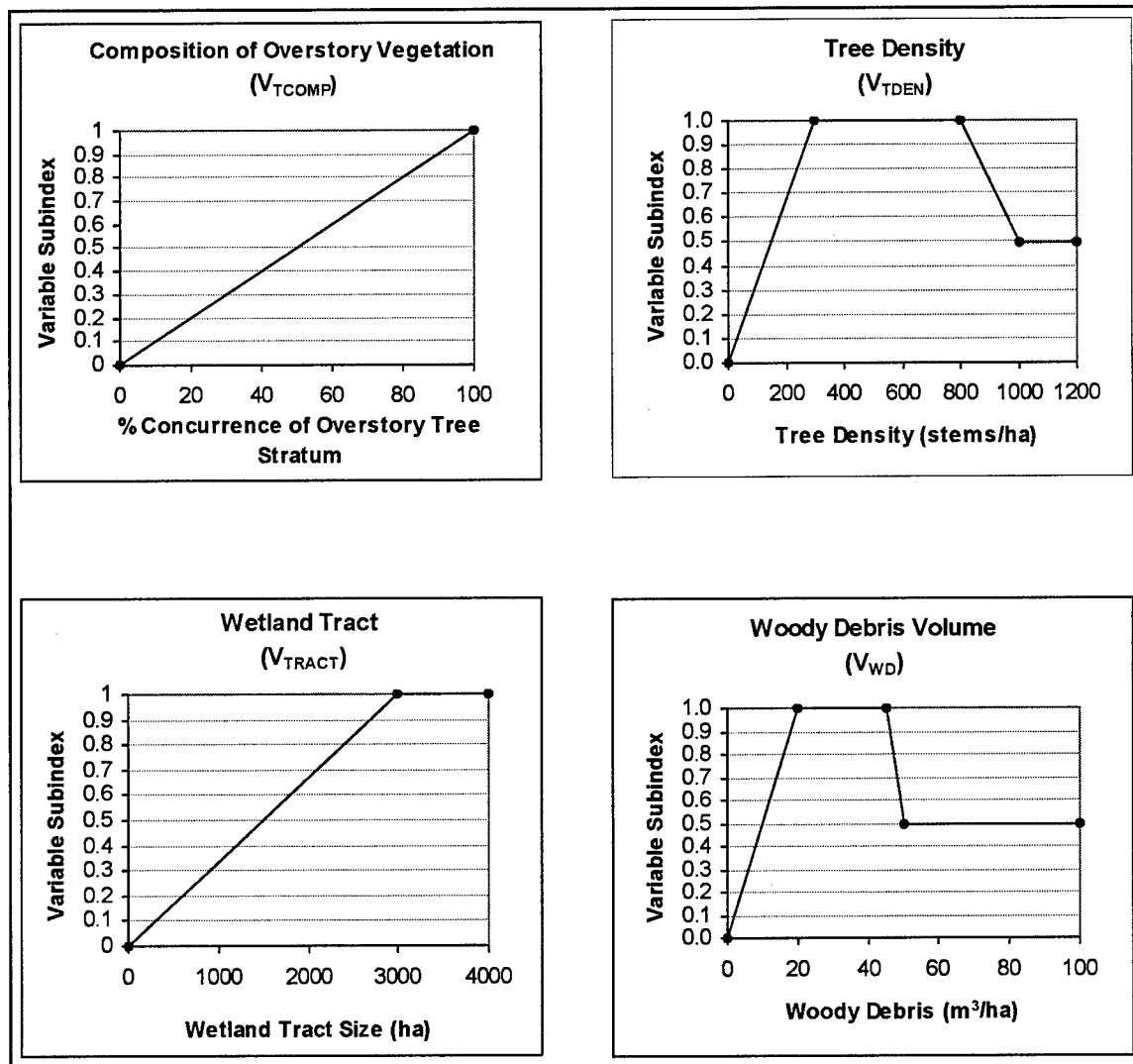


Figure 20. (Sheet 3 of 3)

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right]}{2}$$

g. *Function 7: Provide Wildlife Habitat.* Applicable in the following modified form:

$$FCI = \left\{ \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \times \left[ \frac{(V_{LOG} + V_{OHCR})}{2} \right] \right\}^{1/3} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \left\{ \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right] \right\}^{1/2}$$

## Subclass: Connected Depression

Six functions are assessed for this subclass as follows. Some of the models have been modified from the general model form presented in Chapter 4. Figure 21 provides the relationship between the variable metrics and the sub-index for each of the assessment variables based on the connected depression reference data.

a. *Function 1: Detain Floodwater.*

$$FCI = V_{FREQ} \times \left[ \frac{(V_{LOG} + V_{GVC} + V_{SSD} + V_{TDEN})}{4} \right]$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = V_{FREQ} \times \left[ \frac{(V_{SSD} + V_{TDEN})}{2} \right]$$

b. *Function 2: Detain Precipitation.* Not assessed.

c. *Function 3: Cycle Nutrients.* Applicable in the following modified form:

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{SSD} + V_{GVC})}{3} + \frac{(V_{OHOR} + V_{AHOR} + V_{WD} + V_{SNAG})}{4} \right]}{2}$$

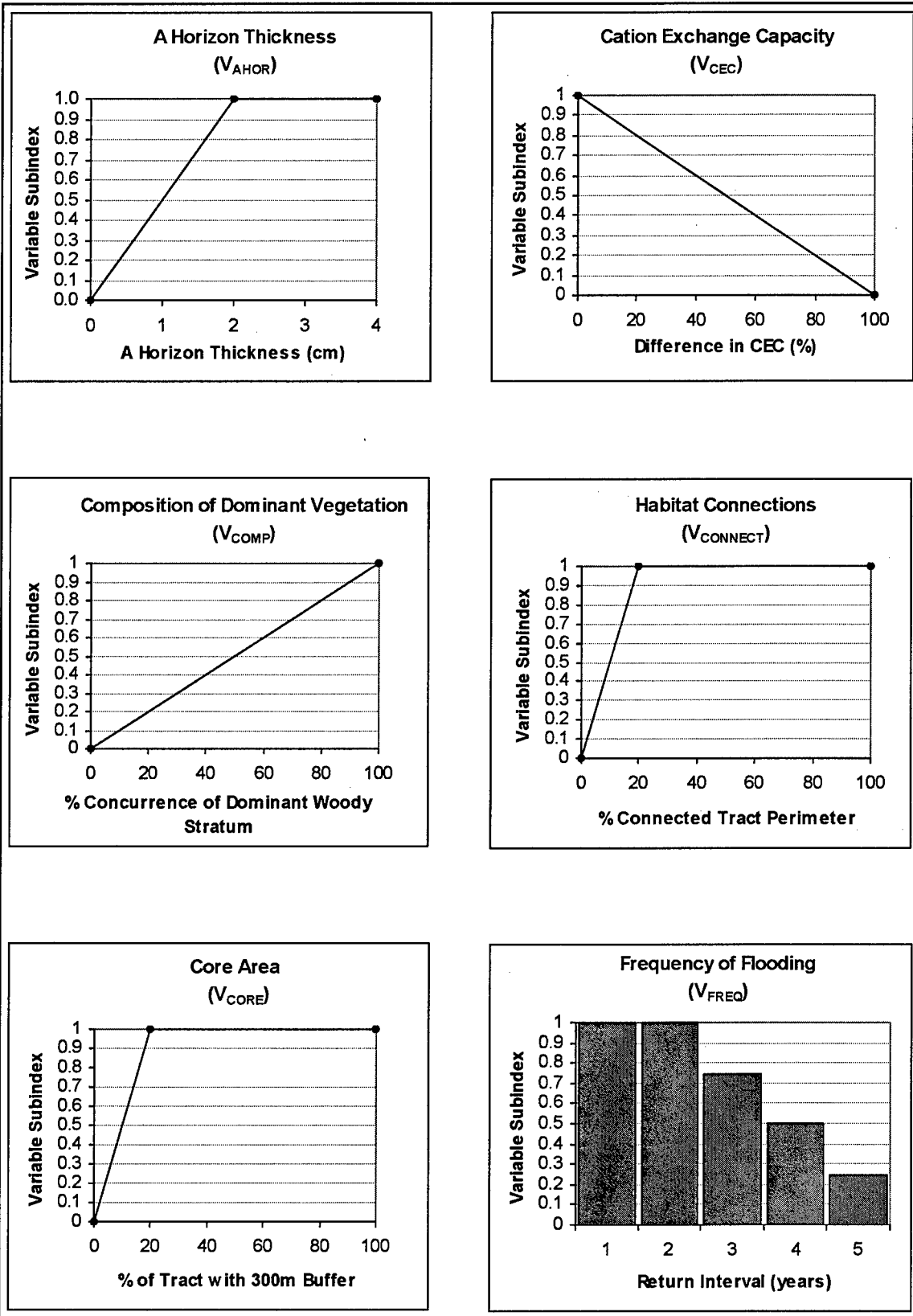


Figure 21. Subindex graphs for Connected Depression wetlands (Sheet 1 of 4)

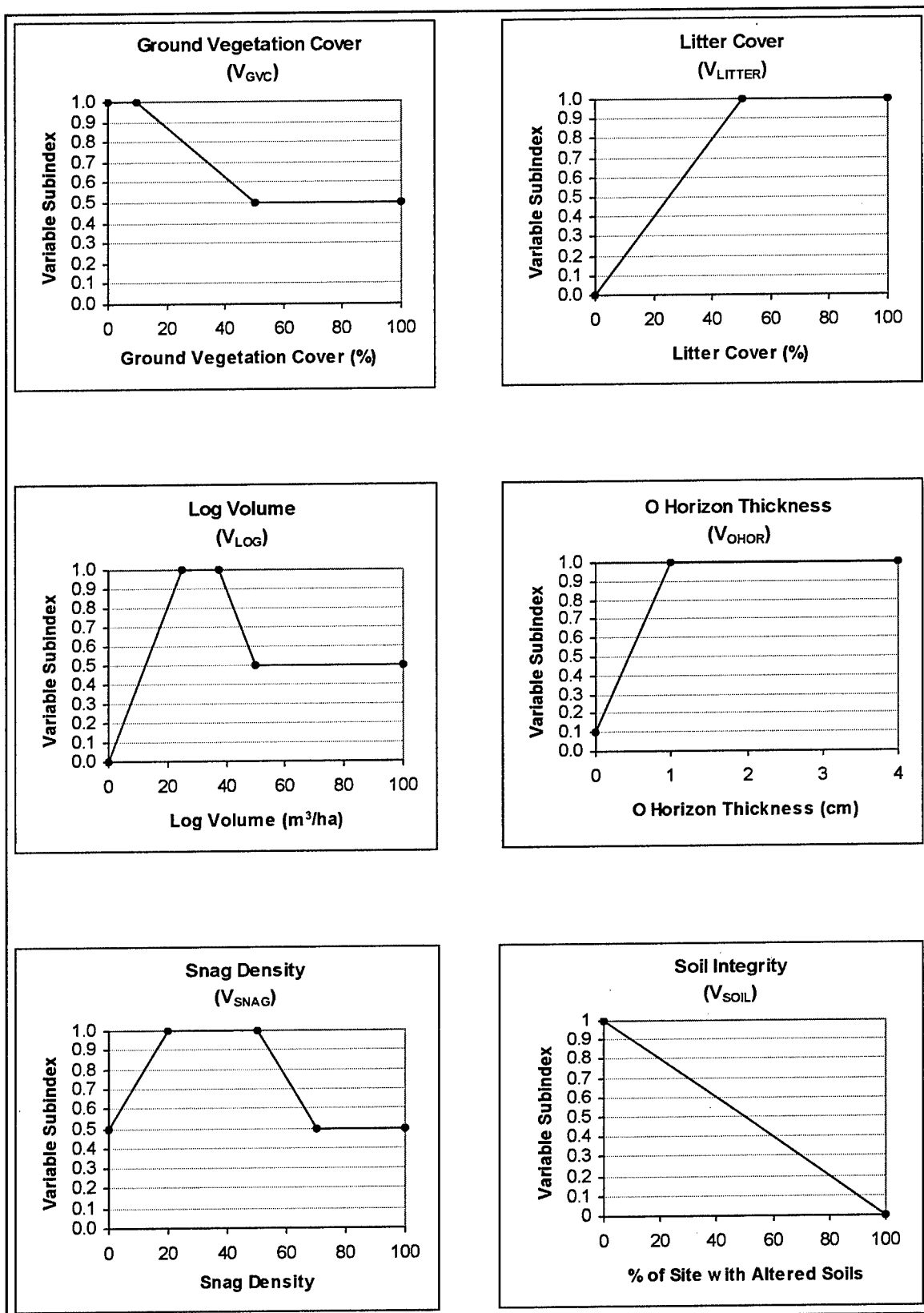


Figure 21. (Sheet 2 of 4)

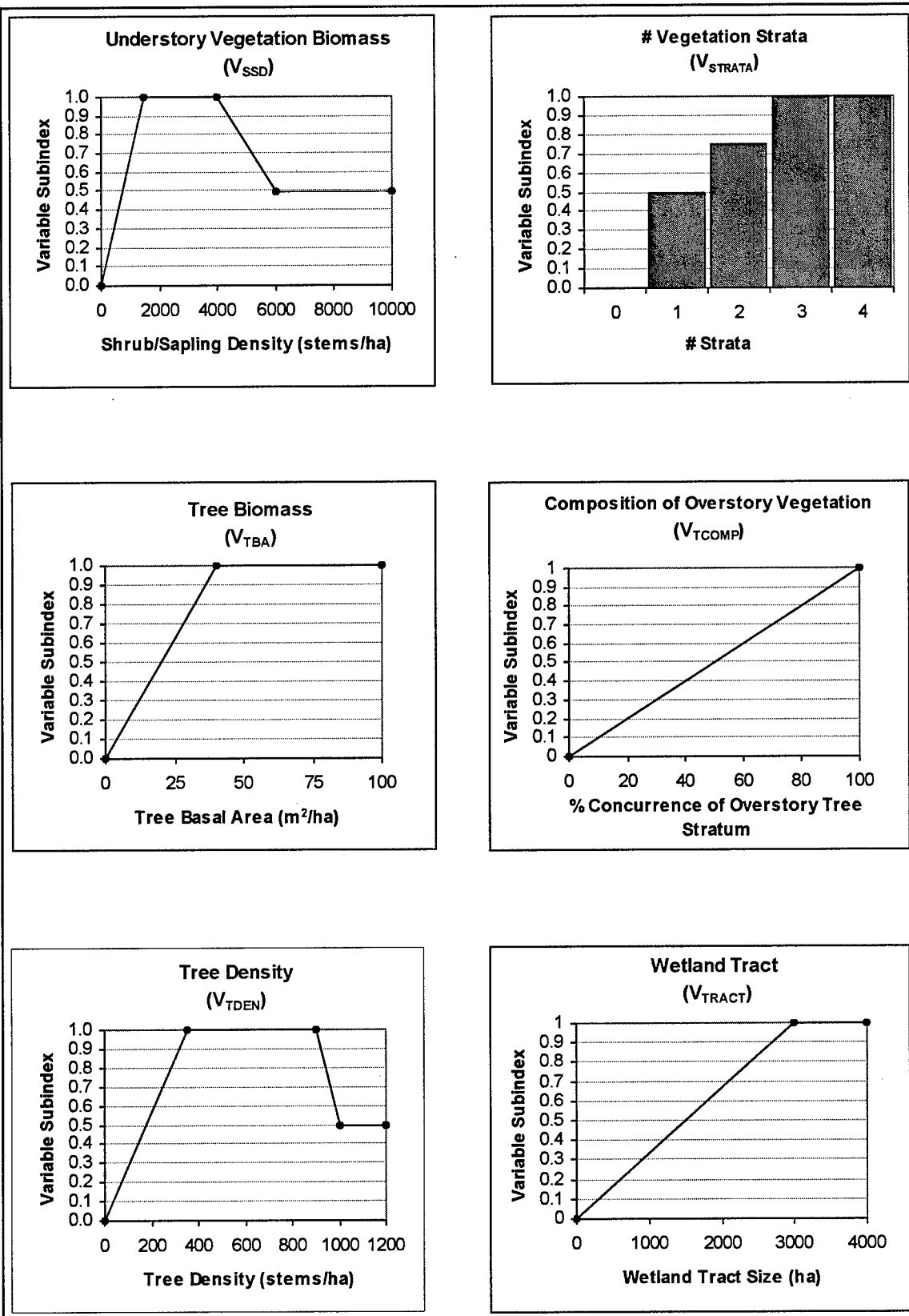


Figure 21. (Sheet 3 of 4)

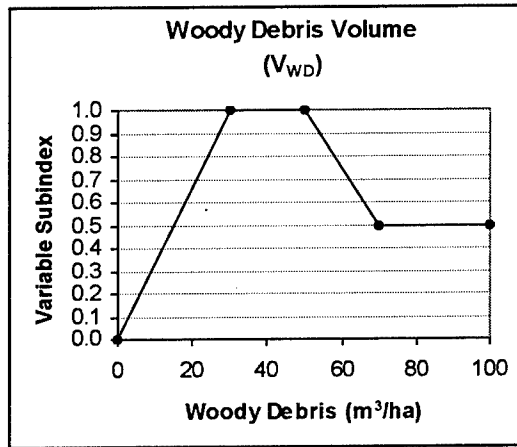


Figure 21. (Sheet 4 of 4)

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3}$$

- d. *Function 4: Export Organic Carbon.* Applicable in the following modified form:

$$FCI = V_{FREQ} \times \frac{\left[ \frac{(V_{LITTER} + V_{OHOR} + V_{WD} + V_{SNAG})}{3} \right] + \left[ \frac{V_{TBA} + V_{SSD} + V_{GVC}}{3} \right]}{2}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = V_{FREQ} \times \left[ \frac{(V_{TBA} + V_{SSD} + V_{SNAG})}{3} \right]$$

- e. *Function 5: Remove Elements and Compounds.*

$$FCI = V_{FREQ} \times \left[ \frac{(V_{CEC} + V_{OHOR} + V_{AHOR})}{3} \right]$$

This function is not assessed if ground-level variables cannot be observed due to inundation.

- f. *Function 6: Maintain Plant Communities.* Applicable in the following modified form:



$$FCI = \left( \left[ \frac{\left( \frac{V_{TBA} + V_{TDEN}}{2} + V_{COMP} \right)}{2} \right] \times V_{SOIL} \right)^{1/2}$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \frac{\left[ \frac{(V_{TBA} + V_{TDEN})}{2} + V_{COMP} \right]}{2}$$

- g. *Function 7: Provide Wildlife Habitat.* Applicable in the following modified form:

$$FCI = \left\{ V_{FREQ} \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \times \left[ \frac{(V_{LOG} + V_{OHOR})}{2} \right] \right\}^{1/4} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

Applicable in the following alternate form when inundation prevents observation of ground-level features:

$$FCI = \left\{ V_{FREQ} \times \left[ \frac{(V_{TCOMP} + V_{SNAG} + V_{STRATA} + V_{TBA})}{4} \right] \right\}^{1/3} \times \left[ \frac{(V_{TRACT} + V_{CONNECT} + V_{CORE})}{3} \right]$$

## 6 Assessment Protocol

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### Introduction

Previous chapters of this Regional Guidebook have provided background information on the HGM Approach, characterized regional wetland subclasses, and have documented the variables, functional indices, and assessment models used to assess regional wetland subclasses in the Delta Region of Arkansas. This chapter outlines the procedures for collecting and analyzing the data required to conduct an assessment.

In most cases, permit review, restoration planning, and similar assessment applications require that a comparison be made between pre- and post-project conditions of wetlands at the project site to develop estimates of the loss or gain of function associated with the project. Both the pre- and post-project assessments should be completed at the project site before the proposed project has begun. Data for the pre-project assessment represent existing conditions at the project site, while data for the post-project assessment are normally based on a prediction of the conditions that can reasonably be expected to exist following proposed project impacts. A well-documented set of assumptions should be provided with the assessment to support the predicted post-project conditions used in making an assessment.

Where the proposed project involves wetland restoration or compensatory mitigation, this guidebook can also be used to assess the functional effectiveness of the proposed actions. The final section of this chapter provides recovery trajectory curves for selected variables that may be employed in that analysis.

A series of tasks are required to assess regional wetland subclasses in the Delta Region of Arkansas using the HGM Approach:

- Document the project purpose and characteristics.
- Screen for red flags.
- Define assessment objectives and identify regional wetland subclass(es) present, and assessment area boundaries.
- Collect field data.
- Analyze field data.
- Document assessment results.

- Apply assessment results.

The following sections discuss each of these tasks in greater detail.

## **Document the Project Purpose and Characteristics**

Data Form A1 (Site or Project Information and Assessment Documentation, Figure A1, Appendix A) provides a checklist of information needed to conduct a complete assessment, and serves as a cover sheet for all compiled assessment maps, drawing, data forms, and other information. It requires the assignment of a project name, identification of personnel involved in the assessment, and attachment of supporting information and documentation. The first step in this process is to develop a narrative explanation of the project, with supporting maps and graphics. This should include a description of the project purpose and project area features, which can include information on location, climate, surficial geology, geomorphic setting, surface and groundwater hydrology, vegetation, soils, land use, existing cultural alteration, proposed impacts, and any other characteristics and processes that have the potential to influence how wetlands at the project area perform functions. The accompanying maps and drawings should indicate the locations of the project area boundaries, jurisdictional wetlands, wetland assessment areas (described later in this chapter), proposed impacts, roads, ditches, buildings, streams, soil types, plant communities, threatened or endangered species habitats, and other important features.

Many sources of information will be useful in characterizing a project area:

- Aerial photographs.
- Topographic maps.
- Geomorphic maps (Saucier 1994).
- County soil survey.
- National Wetland Inventory maps.
- Chapter 3 of this Regional Guidebook.

For large projects or complex landscapes, it is usually a good idea to use aerial photos and geomorphic information (from Appendix E) to develop a preliminary classification of wetlands for the project area and vicinity prior to going to the field. Figure 22 illustrates this process for a typical Delta lowland wetland complex. The rough wetland map can then be taken to the field to refine and revise the identification of wetland subclasses.

Attach the completed Project Description and supporting materials to Data Form A1.

### HGM Classes

-  Depression Wetlands
-  Flat Wetlands
-  Fringe Wetlands
-  Riverine Wetlands

0 200 400 800  
Meters

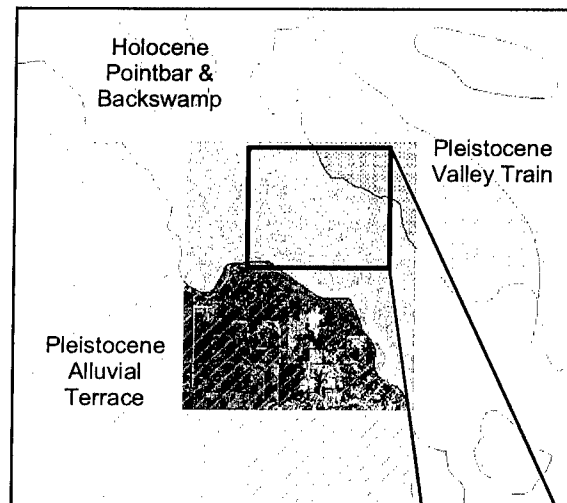


Figure 22. Example application of geomorphic mapping and aerial photography to develop a preliminary wetland classification for a proposed project area

## Screen for Red Flags

Red flags are features in the vicinity of the project area to which special recognition or protection has been assigned on the basis of objective criteria (Table 8). Many red flag features, based on national criteria or programs, are similar from region to region. Other red flag features are based on regional or local criteria. Screening for red flag features determines if the wetlands or other natural resources around the project area require special consideration or attention that may preempt or postpone conducting a wetland assessment. For example, if a proposed project has the potential to adversely affect threatened or endangered species, an assessment may be unnecessary since the project may be denied or modified based on the impacts to the protected species alone.

<b>Table 8</b>	
<b>Red Flag Features and Respective Program/Agency Authority</b>	
<b>Red Flag Features</b>	<b>Authority<sup>1</sup></b>
Native Lands and areas protected under American Indian Religious Freedom Act	A
Hazardous waste sites identified under Comprehensive Environmental Response, Compensation, and Liability Act (Super Fund) (CERCLA) or Resource Conservation and Recovery Act (RCRA)	I
Areas providing Critical Habitat for Species of Special Concern	C
Areas covered under the Farmland Protection Act	K
Floodplains, floodways, or floodprone areas	J
Areas with structures/artifacts of historic or archeological significance	G
Areas protected under the Land and Water Conservation Fund Act	K
National Wildlife Refuges and special management areas	C
Areas identified in the North American Waterfowl Management Plan	C, F
Areas identified as significant under the Ramsar Treaty	H
Areas supporting rare or unique plant communities	C, H
Areas designated as Sole Source Groundwater Aquifers	I, L, M
Areas protected by the Safe Drinking Water Act	E, I, L
City, County, State, and National Parks	B, D, H, L
Areas supporting threatened or endangered species	C, F, H, I
Areas with unique geological features	H
Areas protected by the Wild and Scenic Rivers Act or Wilderness Act	D
State wetland mitigation banks	M
<sup>1</sup> Program Authority / Agency A = Bureau of Indian Affairs B = Arkansas State Parks C = U.S. Fish and Wildlife Service D = National Park Service (NPS) E = Arkansas Department of Environmental Quality F = Arkansas Game and Fish Commission G = State Historic Preservation Officer (SHPO) H = Arkansas Natural Heritage Commission I = U.S. Environmental Protection Agency J = Federal Emergency Management Administration K = Natural Resource Conservation Service L = Local Government Agencies M = Arkansas Soil and Water Conservation Commission	

## **Define Assessment Objectives, Identify Regional Wetland Subclass(es) Present, and Identify Assessment Area Boundaries**

Begin the assessment process by unambiguously stating the objective of conducting the assessment. Most commonly, this will be simply to determine how a proposed project will impact wetland functions. However, there are other potential objectives:

- Compare several wetlands as part of an alternatives analysis.
- Identify specific actions that can be taken to minimize project impacts.
- Document baseline conditions at a wetland site.
- Determine mitigation requirements.
- Determine mitigation success.
- Evaluate the likely effects of a wetland management technique.

Frequently, there will be multiple objectives, and defining these objectives in a clear and concise manner will facilitate communication and understanding among those involved in conducting the assessment, as well as other interested parties. In addition, it will help to define the specific approach and level of effort that will be required to conduct assessments. For example, the specific approach and level of effort will vary depending on whether the project is a 404 individual permit review, an Advanced Identification (ADID) project, a Special Area Management Plan (SAMP), or some other assessment scenario.

Figures 23 through 26 present a simplified project scenario to illustrate the steps used to designate the boundaries of Wetland Assessment Areas (WAA), each of which will require a separate HGM assessment. Figure 23 illustrates a land cover map for a hypothetical project area. Figure 24 shows the project area (in yellow) superimposed on the land cover map. To determine the boundaries of the WAAs, first use the Keys to Wetland Classes and Subclasses (Figures 10 and 11) and identify the wetland subclasses within and contiguous to the project area (Figure 25). Overlay the project area boundary and the wetland subclass boundaries to identify the WAAs for which data will be collected (Figure 26). Attach these maps, photos, and drawings to Data Form A1 and complete the first three columns of the table on Data Form A1 by assigning an identifying number to each WAA, specifying the subclass it belongs to, and calculating the area in hectares.

Each WAA is a portion of the project area that belongs to a single regional wetland subclass and is relatively homogeneous with respect to the criteria used to assess wetland functions (i.e., hydrologic regime, vegetation structure, topography, soils, successional stage). However, as the size and heterogeneity of the project area increase, it is more likely that it will be necessary to define and assess multiple WAAs within a project area.

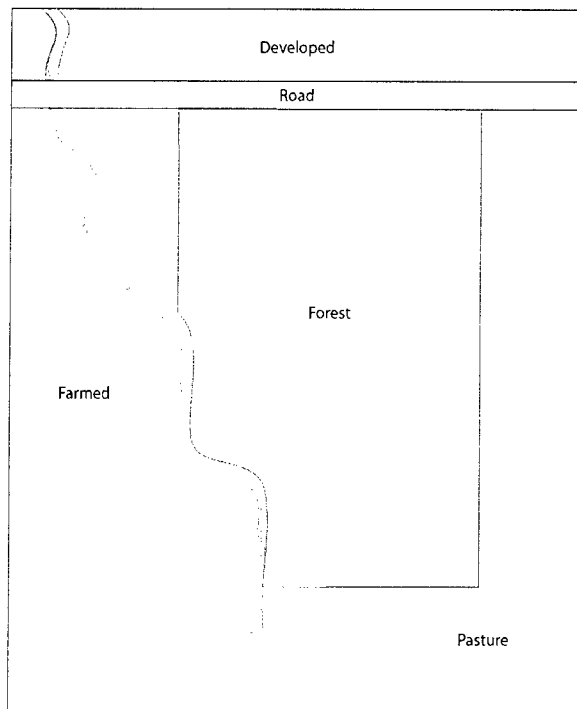


Figure 23. Land cover

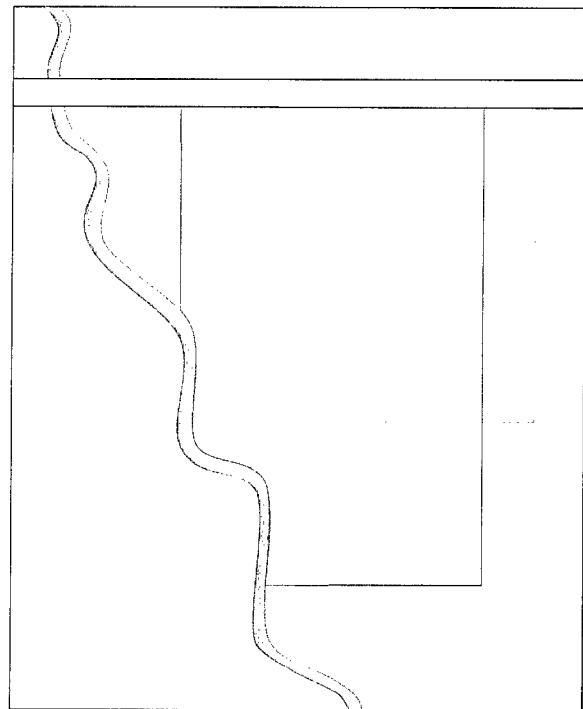


Figure 24. Project area (in yellow)

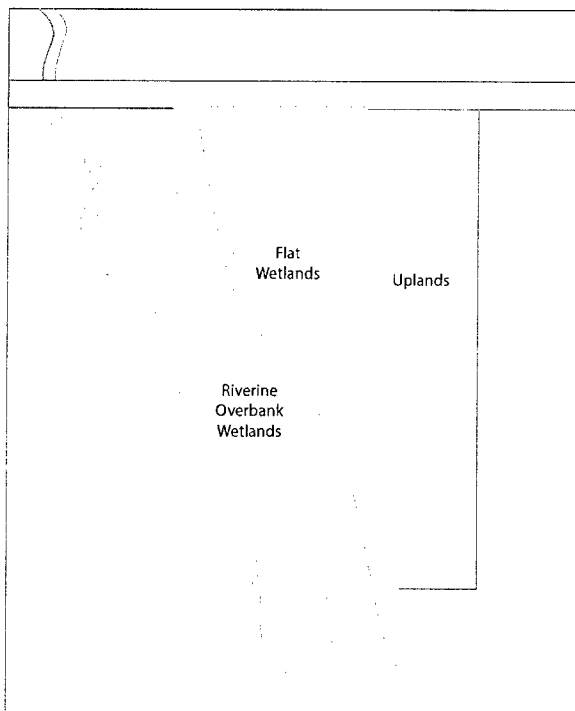


Figure 25. Wetland subclasses (purple line indicates extent of the "wetland tract")

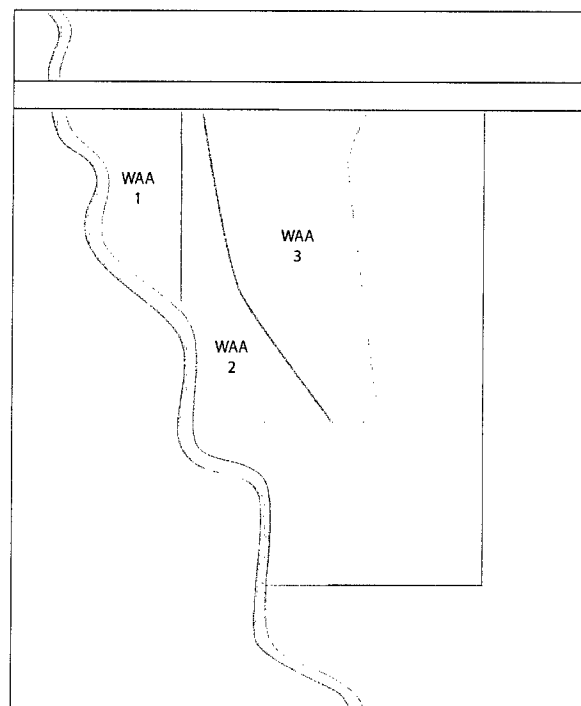


Figure 26. WAAs

At least three situations can be identified that necessitate defining and assessing multiple WAAs within a project area. The first situation occurs when widely separated areas of wetlands belonging to the same regional subclass occur in the project area. Such noncontiguous wetlands must be designated as separate WAAs, because the assessment process includes consideration of the size and isolation of individual wetland units. The second situation occurs where more than one regional wetland subclass occurs within a project area, as illustrated in Figure 25, where both Flat and Low-gradient Riverine Overbank wetlands are present within the project area. These must be separated because they are assessed using different models and reference data systems. The third situation occurs where a contiguous wetland area of the same regional subclass exhibits spatial heterogeneity in terms of hydrology, vegetation, soils, or other assessment criteria. This is illustrated in Figure 26, where the area designated as Riverine Overbank Wetlands in Figure 25 is further subdivided into two WAAs based on land use and vegetation cover. The farmed area clearly will have different characteristics from those of the forested wetland, and they will be assessed separately (though using the same models and reference data).

In the Delta Region of Arkansas, the most common scenarios requiring designation of multiple WAAs involve tracts of land with interspersed regional subclasses (such as depressions scattered within a matrix of flats or riverine wetlands) or tracts composed of a single regional subclass that includes areas with distinctly different land use influences that produce different land cover. For example, within a large riverine backwater unit, the following WAAs may be defined: cleared land, early successional sites, and mature forests. However, be cautious about splitting a project area into many WAAs based on relatively minor differences, such as local variation due to canopy gaps and edge effects. The reference curves used in this document (Chapter 5) incorporate such variation, and splitting areas into numerous WAAs based on subtle differences will not materially change the outcome of the assessment. It will, however, greatly increase the sampling and analysis requirements. Field experience in the region should provide a sense of the range of variability that typically occurs, and is sufficient to make reasonable decisions in defining multiple WAAs.

## Collect Field Data

Information on the variables used to assess the functions of regional wetland subclasses in the Delta Region of Arkansas is collected at several different spatial scales, and requires several summarization steps. The checklists and data forms in the appendices are designed to assist the assessment team in assembling the required materials and proceeding in an organized fashion. As noted, the Site or Project Information and Assessment Documentation Form (Appendix A1) is intended to be used as a cover sheet and for an overview of all documents and data forms used in the assessment. Assembling the background information listed on this form should guide the assessment team in determining the number, types, and sizes of the separate WAAs likely to be designated within the project area. Based on that information, the field gear and data form checklists in Appendix A2 should be used to assemble the needed materials before heading to the field to conduct the assessment.



Note that different wetland subclasses require different field data forms, because the assessment variables differ among subclasses (Table 9). Use the Data Form checklist in Appendix A2 to determine how many of each form are needed, then make copies of the required forms, which are provided in Appendix B.

<b>Table 9</b> <b>Applicability of Variables by Regional Wetland Subclass</b>						
<b>Variable Code</b>	<b>Flat</b>	<b>Riverine Backwater</b>	<b>Riverine Overbank</b>	<b>Headwater Depression</b>	<b>Isolated Depression</b>	<b>Connected Depression</b>
V <sub>AHOR</sub>	+	+	+	*	*	*
V <sub>CEC</sub>	not used	+	+	not used	not used	*
V <sub>COMP</sub>	+	+	+	+	+	+
V <sub>CONNECT</sub>	+	+	+	+	+	+
V <sub>CORE</sub>	+	+	+	+	+	+
V <sub>FREQ</sub>	not used	+	+	+	not used	+
V <sub>GVC</sub>	+	+	+	*	*	*
V <sub>LITTER</sub>	+	+	+	*	not used	*
V <sub>LOG</sub>	+	+	+	*	*	*
V <sub>OHOR</sub>	+	+	+	*	*	*
V <sub>POND</sub>	+	+	+	not used	not used	not used
V <sub>SNAG</sub>	+	+	+	+	+	+
V <sub>SOIL</sub>	+	+	+	*	*	*
V <sub>STRATA</sub>	+	+	+	+	+	+
V <sub>SSD</sub>	+	+	+	+	+	+
V <sub>TBA</sub>	+	+	+	+	+	+
V <sub>TCOMP</sub>	+	+	+	+	+	+
V <sub>TDEN</sub>	+	+	+	+	+	+
V <sub>TRACT</sub>	+	+	+	+	+	+
V <sub>WD</sub>	+	+	+	*	*	*
Note: Variables not used in assessment of a particular subclass are identified. Variables always used in assessment of the subclass are indicated by +. Variables used unless site conditions preclude their observation are indicated by a shaded box marked with *.						

The data forms provided in Appendix B are organized to facilitate data collection at each of the several spatial scales of interest. For example, the first group of variables (Data Form 1) contains information about landscape scale characteristics collected using aerial photographs, maps, and hydrologic information regarding each WAA and vicinity. Information on the second group of variables (Data Form 2) is collected during a walking reconnaissance of the WAA. Data collected for these two groups of variables are entered directly on the Data Forms, and do not require plot-based sampling. Information on the next group of variables is collected in sample plots placed in representative locations throughout the WAA. Data from a single plot are recorded on Data Form 3,

which is made up of three separate data sheets. Additional copies of Data Form 3 are completed for each plot sampled within the WAA. All summary data from each of the Data Forms are compiled on Data Form 4 prior to entry into the spreadsheets that calculate the Functional Capacity of the wetland being assessed.

The sampling procedures for conducting an assessment require few tools, but certain tapes, a shovel, specialized basal area estimation or measurement tools, reference materials, and an assortment of other items will be needed (Appendix A2). Generally, all measurements should be taken in metric units (although non-SI equivalents are indicated for most sampling criteria such as plot sizes). Collecting data in non-SI units will require conversion of sample data to metric before completing the necessary calculations of entering data into spreadsheets for summarization. There are two exceptions to this general rule: the recommended basal area prism is a non-SI 10-factor prism, which is an appropriate size for use in the forests of the Delta Region. A conversion factor is built into the data form to make the needed adjustments to the recorded field data. The second instance involves measurement of diameter-at-breast-height (dbh) using a special tape, and calculation of basal area, which is an alternative approach to the prism method. Because non-SI dbh tapes are more widely available than metric tapes, the summarization spreadsheets provided in Appendix D are able to accept either non-SI or metric units as input data.

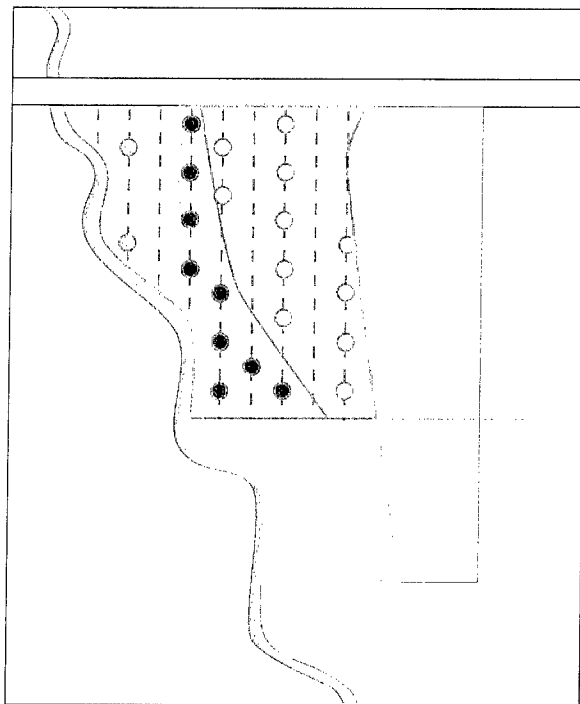


Figure 27. Example sample distribution. Refer to Figure 26 for WAA designations

A typical layout for the establishment of sample plots and transects in the hypothetical WAAs is shown in Figure 27. As in defining the WAA, there are elements of subjectivity and practicality in determining the number of sample locations for collecting plot-based and transect-based site-specific data. The exact numbers and locations of the plots and transects are dictated by the size and heterogeneity of the WAA. If the WAA is relatively small (i.e., less than 2–3 acres, or about a hectare) and homogeneous with respect to the characteristics and processes that influence wetland function, then three or four 0.04-ha plots, with associated nested transects and subplots in representative locations, are probably adequate to characterize the WAA. Experience has shown that the time required to complete an assessment of an area that size is 2–4 hours, depending primarily on the experience of the assessment team. However, as the size

and heterogeneity of the WAA increase, more sample plots are required to represent the site accurately. Large forested wetland tracts usually include a mix of tree age classes, scattered small openings in the canopy that cause locally

dense understory or ground cover conditions, and perhaps some very large individual trees or groups of old-growth trees. The sampling approach should not bias data collection to differentially emphasize or exclude any of these local conditions, but should represent the site as a whole. Therefore, on large sites the best approach often is a simple systematic plot layout, where evenly spaced parallel transects are established (using a compass and pacing) and sample plots are distributed at regular paced intervals along those transects. For example, a 12-ha tract, measuring about 345 m on each side, might be sampled using two transects spaced 100 m apart (and 50 m from the tract edge), with plots at 75-m intervals along each transect (starting 25 m from the tract edge). This would result in eight sampled plot locations, which should be adequate for a relatively diverse 12-ha forested wetland area. In Figure 27, WAA 2 illustrates this approach for establishing fairly high-density, uniformly distributed samples. Larger or more uniform sites can usually be sampled at a lower plot density. One approach is to establish a series of transects, as described, and sample at intervals along alternate transects (see WAA 3 in Figure 27). Continue until the entire site has been sampled at a low plot density, then review the data and determine if the variability in overstory composition and basal area has been largely accounted for. That is, as the number of plots sampled has increased, are new dominant species no longer being encountered, and has the average basal area for the site changed markedly with the addition of recent samples? If not, there is probably no need to add further samples to the set. If overstory structure and composition variability remains high, then return to the alternate, unsampled transects and continue sampling until the data set is representative of the site as a whole, as indicated by a leveling off of the dominant species list and basal area values. Other variables may level off more quickly or slowly than tree composition and basal area, but these two factors are generally good indicators, and correspond well to the overall suite of characteristics of interest within a particular WAA. In some cases, such as sites where trees have been planted or composition and structure are highly uniform (e.g. sites dominated by a single tree species), it may be apparent that relatively few samples are adequate to reasonably characterize the wetland. In Figure 27, this is illustrated by the sample distribution in WAA 1, which is a farmed area where few variables are likely to be measurable, or at least will vary little from plot to plot. In this case, every other plot location is sampled along every other transect.

The information on Data Forms 1 and 2, and on the multiple copies of Data Form 3, are transferred to Data Form 4 where they are summarized and used as input to the spreadsheet that calculates FCI values and Functional Capacity Units (FCUs) for each WAA. All of the field and summary data forms, as well as the printed output from the final spreadsheet calculations, should be attached to the Project Information and Assessment Documentation Form provided in Appendix A. Appendix C provides some alternate data forms that may be needed in cases where alternative field methods are used, or where the user wishes to calculate summary data by hand, rather than using the spreadsheets. The use of these forms is explained on the forms themselves, and in the pertinent variable descriptions below. Appendix D contains the spreadsheets (in Excel format) that are recommended for completing the data summary calculations. Appendix F is a listing of common and scientific names of tree and shrub species that are referenced on the field data forms.

Detailed instructions on collecting the data for entry on Data Forms 1, 2, and 3 are provided in the following sections. Variables are listed in alphabetical order to facilitate locating them. Each set of directions results in an overall WAA value for the variable entered on Data Form 4. Those numbers are then used in the final spreadsheet (Appendix D) to complete the assessment calculations.

Not all variables are used to assess all subclasses, as described in Chapter 5 and Table 9, but the data forms in Appendix B indicate which variables are pertinent to each subclass. The data forms also provide brief summaries of the methods used to assess each variable, but the user should read through these more detailed descriptions and have them available in the field for reference as necessary.

### **$V_{AHOR}$ - A Horizon Organic Accumulation**

This variable represents total mass of organic matter in the A soil horizon. The A soil horizon is defined as a mineral soil horizon that occurs at the ground surface, below the O soil horizon, consisting of an accumulation of unrecognizable decomposed organic matter mixed with mineral soil (USDA SCS 1993). In practice, the HGM models using this variable are concerned with the storage of organic matter, so for these purposes the A horizon is identified in the field simply as a zone of darkened soil.

Thickness of the A horizon is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Establish sample points by selecting two or more locations within the 0.04-ha circular plot that are representative of the range of micro-topographic conditions in the plot, or select two or more of the four 1-m<sup>2</sup> subplots established for litter and ground cover estimation (see descriptions of those variables). Dig a hole (25 cm or 10 in. deep is usually adequate in the Delta Region) and measure the thickness of the A horizon. Record measurements on Data Form 3, and calculate the average value for the plot as indicated on that form.
- (2) Transfer the average plot value to Data Form 4. Calculate an overall WAA average on that form and enter in the right-hand column.

### **$V_{CEC}$ - Cation Exchange Capacity**

This variable represents change in the CEC of a soil as indicated by the total change in clay content in the top 50 cm (20 in.) of the soil profile. Most impacts do not significantly change the CEC of the soil profile. However, some impacts such as the placement of fill material or the excavation and replacement of soil can significantly alter CEC and increase or decrease the capacity of a wetland area to retain elements and compounds.

The percent difference in CEC in the top 50 cm (20 in.) of the soil profile in the WAA is used to quantify this variable. Measure it using the following procedure:

- (1) Determine if the native soil in any of the area being assessed has been covered with fill material, excavated, replaced, or subjected to any other types of impact that significantly change the clay content of the soil profile. If no such alteration has occurred, record a zero percent difference on Data Form 2 in the box on the right-hand side of the  $V_{CEC}$  row. A value of zero indicates that the CEC of soils in the assessment area has not been altered as a result of changes in clay content.
- (2) If areas of disturbed soil exist in the WAA, use the CEC worksheet and reference table on Data Form 2 to calculate the percent change in CEC. Determine what percentage of the WAA each disturbed area represents, and record the percent of the area as a decimal fraction on the CEC worksheet in column 4. If multiple altered areas occur, record what percentage of the WAA each area represents on a separate row in the CEC worksheet (i.e., Altered Area 1, Altered Area 2, etc.).
- (3) Determine or estimate what the CEC of the soil in each altered area was prior to disturbance. Do this based on the map unit identified in the county soil survey and the CEC values in the CEC Reference Table on Data Form 2. Record this value on Data Form 2 in Column 3 of the CEC Worksheet.
- (4) Estimate the CEC of the disturbed soil in each altered area. This is accomplished by a field estimate of soil texture class. Record this value on Data Form 2 in Column 2 of the CEC Worksheet.
- (5) Calculate the difference in CEC between the natural and disturbed soils for each altered area, using the CEC Worksheet on Data Form 2. This is accomplished by taking the absolute value of Column 1 – Column 2. Then multiply this number by the percentage of the assessment area affected, and record the result in Column 5.
- (6) Sum the values in Column 5 of the Worksheet and transfer that number to the right-hand column in the  $V_{CEC}$  row on Data Form 4.

### **$V_{COMP}$ - Composition of Tallest Woody Vegetation Stratum**

This variable represents the species composition of the tallest woody stratum present in the assessment area. This could be the tree, shrub-sapling, or seedling stratum. Percent concurrence with reference wetlands of the dominant species in the dominant vegetation stratum is used to quantify this variable. Measure it using the following procedure:

- (1) Determine percent cover of the tree stratum by visually estimating what percentage of the sky is blocked by leaves and stems of the tree stratum, or vertically projecting the leaves and stems to the forest floor. If the

percent cover of the tree stratum is estimated to be at least 20 percent, go to Step 2. If the percent cover of the tree stratum is estimated to be <20 percent, skip Step 2 and go directly to Step 3.

- (2) If the tree stratum has at least 20 percent cover, then the value for  $V_{COMP}$  will be the same as the value for  $V_{TCOMP}$ . In this case, skip the remaining steps and simply enter the  $V_{TCOMP}$  value (see  $V_{TCOMP}$  discussion) in the box at the right-hand side of the  $V_{COMP}$  row on Data Form 3, then transfer the  $V_{COMP}$  plot value to Data Form 4. Calculate an overall WAA average on that form and enter in the right-hand column.
- (3) If the tree stratum does not have at least 20 percent cover, determine the tallest woody stratum with at least 10 percent total cover. Within this stratum, identify the dominant species based on percent cover using the 50/20 rule (U.S. Army Corps of Engineers 1992): rank species in descending order of percent cover and identify dominants by summing relative dominance in descending order until 50 percent is exceeded; additional species with 20 percent relative dominance should also be included as dominants. Circle these species on Data Form 3 of the appropriate wetland subclass. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.
- (4) Calculate percent concurrence using the formula provided on Data Form 3, which weights dominant species based on their likelihood of being dominant in reference stands of varying condition. The result is intended to indicate the character of the developing forest.
- (5) Record the percent concurrence value in the box at the right-hand side of the  $V_{COMP}$  row on Data Form 3.
- (6) Transfer the  $V_{COMP}$  plot value to Data Form 4. Calculate an overall WAA average on that form and enter in the right-hand column.

### **$V_{CONNECT}$ - Habitat Connectivity**

This variable is defined as the proportion of the perimeter of a forested wetland tract that is connected to suitable wildlife habitat such as upland forests or other wetlands vegetated with native species (Figure 28). Agricultural fields, orchards, clear cuts, pastures dominated by non-native species, mined areas, and developed areas are examples of unsuitable habitats, regardless of whether they meet the criteria for federally jurisdictional wetlands or not. Note that because this is a landscape-level variable, the "tract" is not limited to the WAA under consideration, but includes all contiguous forested wetlands (Figure 25).

The percentage of the forested wetland tract boundary that is “connected” is used to quantify this variable. Note that the “tract” is not limited to the WAA under consideration, but includes all contiguous forested wetlands. An adjacent habitat is considered connected if it is within 0.5 km (0.31 mile) of the boundary of the forested wetland tract. Measure it using the following procedure:

- (1) Calculate the length of the forested wetland tract boundary. Use field reconnaissance, topographic maps, aerial photography, Geographic Information System (GIS), or another suitable method or tool.
- (2) Calculate the length of the forested wetland tract boundary that is within 0.5 km (0.31 mile) of suitable habitats like those described previously.
- (3) Divide the length of connected forested wetland tract boundary by the length of the total forested wetland tract boundary, and then multiply by 100. The resulting number is the percent of the wetland tract boundary that is connected.
- (4) Record this percentage on Data Form 1 in the box on the right-hand side of the  $V_{CONNECT}$  row, and transfer that number to the right-hand column in the  $V_{CONNECT}$  row on Data Form 4.

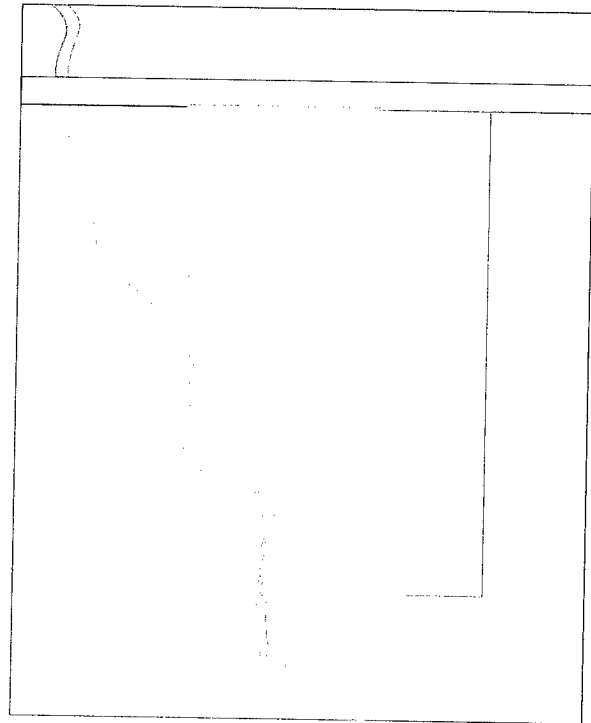


Figure 28. Identification of “connected perimeter” (green line). Refer to Figure 25 for subunit designations

### **$V_{CORE}$ - Core Area**

This variable is defined as the portion of a wetland tract that lies to the inside of a 100-m (330-ft) buffer interior of the boundary of the entire forested area (Figure 29). The percentage of a wetland tract that lies to the inside of this 100-m (330-ft) buffer zone is the metric used to quantify this variable. Note that the tract is not limited to the WAA under consideration, but includes all contiguous forested wetlands. Determine the value of this metric using the following procedure:

- (1) On a map or photo, draw a continuous line 100 m inside the boundary of the entire contiguous forested area.
- (2) Calculate the size of the wetland tract that lies inside this line. This is the core area.

- (3) Divide the size of the core area by size of the wetland tract and then multiply by 100. The resulting number is the percent of the wetland tract that is the core area.
- (4) Record the percentage on Data Form 1 in the box on the right-hand side of the  $V_{CORE}$  row, and transfer the same number to the box on the right-hand side of the  $V_{CORE}$  row on Data Form 4.

### **$V_{FREQ}$ - Frequency of Flooding**

Frequency of flooding refers to the frequency with which overbank or back-water flooding from a stream inundates the WAA. Ideally, characterization of hydrologic regimes would also consider flood depth and duration. However, obtaining these data for a particular assessment area typically requires considerably more time and effort than is normally available under a rapid assessment scenario. Consequently, recurrence interval in years is used to quantify this variable. Determine this value using the following procedure:

- (1) Determine recurrence interval using one of the following methods:
  - Recurrence interval map.
  - Data from a nearby stream gauge.
  - Regional flood frequency curves developed by local and State offices of USACE, U.S. Geologic Survey Water Resources Division, State Geologic Surveys, or NRCS (Jennings et al. 1994).
  - Hydrologic models such as HEC-2 (USACE 1981, 1982), HEC-RAS (USACE 1997), or HSPF (Bicknell et al. 1993).
  - Local knowledge.
  - A regional dimensionless rating curve.
- (2) Record the recurrence interval on Data Form 1 in the box at the right hand side of the  $V_{FREQ}$  row, and transfer the same number to the box on the right hand side of the  $V_{FREQ}$  row on Data Form 4.

Note that the  $V_{FREQ}$  variable is defined somewhat differently for Headwater Depression wetlands (see Chapter 5), where it indicates the frequency at which water is exported from the wetland as streamflow. In that case, local

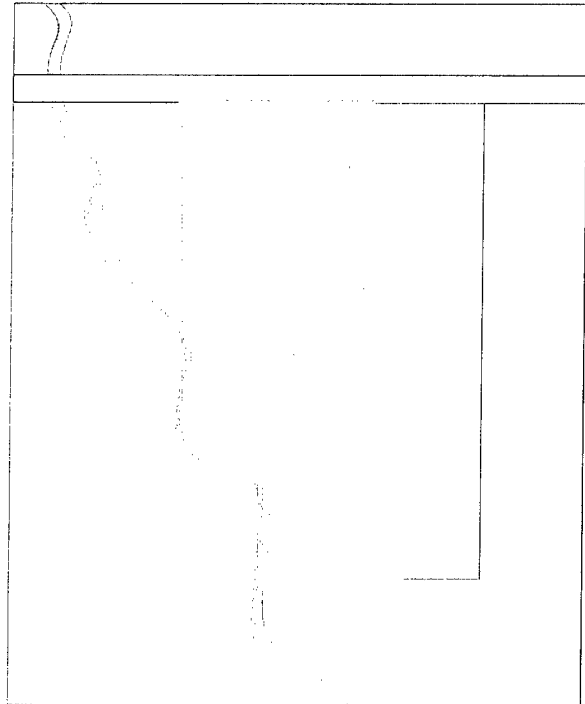


Figure 29. Identification of "core area." Refer to Figure 25 for subunit designations



knowledge of streamflow patterns is likely to be the best available hydrologic information. However, if topographic maps show perennial streams draining the headwater depression, it can be assumed that flood frequency is annual.

### **$V_{GVC}$ - Ground Vegetation Cover**

Ground vegetation cover is defined as herbaceous and woody vegetation less than or equal to 1.4 m (4.5 ft) in height. The percent cover of ground vegetation is used to quantify this variable. Determine the value of this metric using the following procedure:

- (1) Visually estimate the proportion of the ground surface that is covered by ground vegetation by mentally projecting the leaves and stems of ground vegetation to the ground surface. Do this in each of four 1-m<sup>2</sup> subplots placed 5 m (15 ft) from the plot center, one in each cardinal direction as illustrated in Figure 30. Record measurements for each subplot on Data Form 3, and enter the average value for the entire plot in the right-hand column of the  $V_{GVC}$  row on Data Form 3.
- (2) Transfer the average plot value to the  $V_{GVC}$  row on Data Form 4, and average all plot values in the block in the right-hand column.

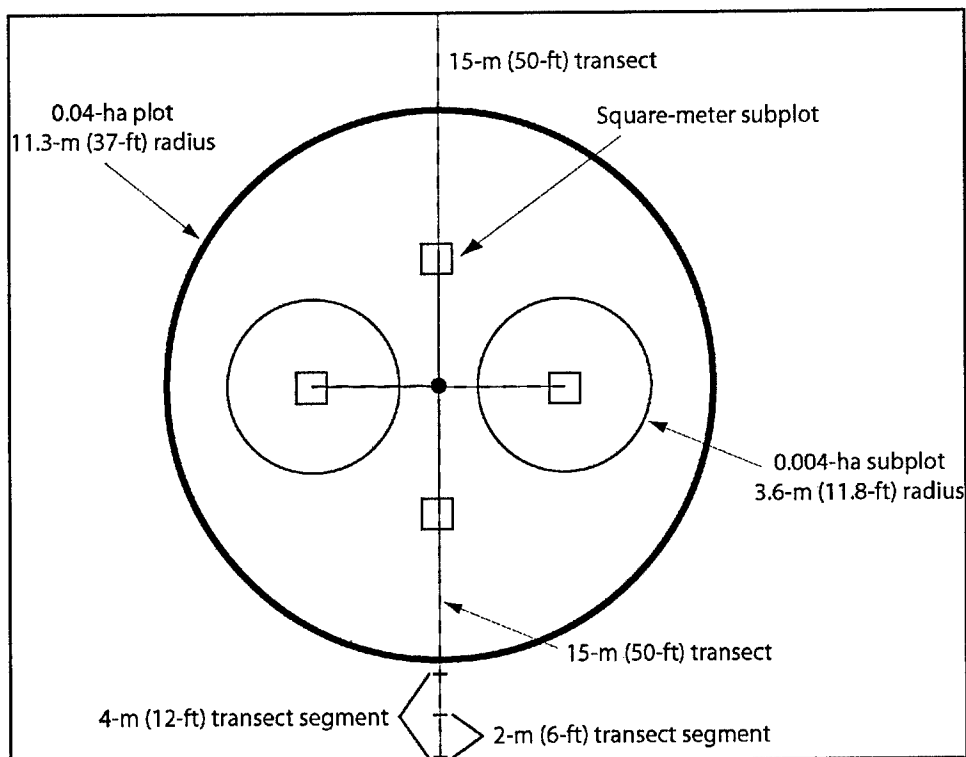


Figure 30. Layout of plots and transects for field sampling

### **$V_{LITTER}$ - Litter Cover**

Litter cover is estimated as the average percent of the ground surface covered by recognizable dead plant materials (primarily decomposing leaves and twigs). This estimate excludes undecomposed woody material large enough to be tallied in the woody debris transects (i.e., twigs larger than 0.6 cm (0.25 in.) in diameter — see  $V_{WD}$  discussion). It also excludes organic material sufficiently decayed to be included in the estimate of O horizon thickness (see  $V_{OHOR}$  discussion). Generally, litter cover is easily recognized and estimated except during autumn, during active leaf fall, when freshly fallen materials should be disregarded in making the estimate, because the volume of freshly fallen material will inflate cover estimates.

The percent cover of litter is used to quantify this variable. Determine the value of this metric using the following procedure:

- (1) Visually estimate the proportion of the ground surface that is covered by litter. Do this in each of the four 1-m<sup>2</sup> subplots (the same subplots established for estimating ground vegetation cover, Figure 30). Record measurements for each subplot on Data Form 3, and enter the average value for the entire plot in the right-hand column of the  $V_{LITTER}$  row on Data Form 3.
- (2) Transfer the average plot value to the  $V_{LITTER}$  row on Data Form 4, and average all plot values in the block in the right-hand column.

### **$V_{LOG}$ - Log Biomass**

See discussion in the Woody Debris ( $V_{WD}$ ) and Log Biomass ( $V_{LOG}$ ) section later in this chapter.

### **$V_{OHOR}$ - O Horizon Organic Accumulation**

The O horizon is defined as the soil layer dominated by organic material that consists of partially decomposed organic matter such as leaves, needles, sticks or twigs < 0.6 cm in diameter, flowers, fruits, insect frass, dead moss, or detached lichens on or near the surface of the ground (USDA SCS 1993). The O horizon does not include recently fallen material or material that has been incorporated into the mineral soil.

Thickness of the O soil horizon is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Measure the thickness of the O horizon in the same holes dug to determine the thickness of the A horizon discussed previously. That will result in two or more measurements per plot, which are recorded as subplot values in the  $V_{OHOR}$  section of Data Form 3.

- (2) Average the O horizon thickness measurements from each of the subplots, and record the average on Data Form 3 in the  $V_{OHOR}$  row as a plot value.
- (3) Transfer the average plot value to the  $V_{OHOR}$  row on Data Form 4. Average all plot values on that form and record in the box at the right-hand side of the  $V_{OHOR}$  row.

### **$V_{POND}$ - Total Poned Area**

Total Poned Area refers to the percent of the WAA ground surface likely to collect and hold precipitation for periods of days or weeks at a time. (Note: This is distinct from the area that is prone to flooding, where the surface of the WAA is inundated by overbank or backwater connections to stream channels). The smaller (microtopographic) depressions are usually a result of tree “tip ups” and the scouring effects of moving water, and typically they are between 1 and 10 m<sup>2</sup> in area. Larger vernal pools (usually at least 0.04 ha) occur in the broad swales typical of meander scroll topography, or in other areas where impeded drainage produces broad, shallow pools during rainy periods. The wetlands where these features are important typically have a mix of both the small microdepressions and the larger vernal pools.

Estimate total ponded area using the following procedure:

- (1) During a reconnaissance walkover of the entire WAA, estimate the percentage of the assessment area surface having microtopographic depressions and vernal pool sites capable of ponding rainwater. Base the estimate on the actual presence of water immediately following an extended rainy period if possible, but during dry periods use indicators such as stained leaves or changes in ground vegetation cover. Generally, it is not difficult to visualize the approximate percentage of the area subject to ponding, but it is important to base the estimate on a walkover of the entire assessment area.
- (2) Report the percent of the assessment area subject to ponding on Data Form 2 in the box on the right-hand side of the  $V_{POND}$  row, and transfer that value to the  $V_{POND}$  box on Data Form 4. Note that, in the case of the Flats subclass, Data Form 4 also requires identification of the geomorphic surface on which the WAA is located, because percent ponding differs markedly among surfaces in the reference data set, which is reflected in the calibration curves and the summary spreadsheets. The geomorphic surface can be identified using the supplemental spatial data in Appendix E, or the map in Figure 6 may be adequate in many cases. Assign the WAA to one of three possible surfaces:
  - Pleistocene Alluvial Terraces (formed by Pleistocene meander activity), identified as “alluvial (meandering stream) terraces” in the Pleistocene legend in Figure 6, and by map unit codes that begin with the following letters in Appendix E: Pt, Pd, Pi, Pp, and Qt.

- Pleistocene Valley Train deposits (formed by glacial outwash events), identified as all Pleistocene surfaces other than terraces in Figure 6, and by map unit codes that begin with the letters Pv in Appendix E.
- Holocene Alluvium (post-glacial meander belts), identified as all Holocene features in Figure 6, and by map unit codes that begin with the letter H in Appendix E.

### **$V_{SNAG}$ - Snag Density**

Snags are standing dead woody stems at least 1.4 m (4.5 ft) tall with a dbh greater than or equal to 10 cm (4 in.). The density of snag stems per hectare is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Count the number of snag stems within each 0.04-ha circular plot. Record the number of snag stems in the indicated box on the  $V_{SNAG}$  row on Data Form 3. Multiply this number by 25 and enter the result in the right-hand box on the  $V_{SNAG}$  row on Data Form 3.
- (2) Transfer snag density per hectare as a plot value to the  $V_{SNAG}$  row on Data Form 4, and enter the average of all of the plot values on that form in the right-hand box of the  $V_{SNAG}$  row.

### **$V_{SOIL}$ - Soil Integrity**

It is difficult in a rapid assessment context to assess soil integrity for two reasons. First, a variety of soil properties contribute to integrity that should be considered (i.e., structure, horizon development, texture, bulk density). Second, the spatial variability of soils within many wetlands makes it difficult to collect the number of samples necessary to characterize a site adequately. Therefore, the approach used here is to assume that soil integrity exists where evidence of alteration is lacking. Stated another way, if the soils in the assessment area do not exhibit any of the characteristics associated with alteration, it is assumed that the soils are similar to those occurring in the reference standard wetlands and have the potential to support a characteristic plant community.

This variable is measured as the proportion of the assessment area with altered soils. Measure it with the following procedure:

- (1) As part of the reconnaissance walkover of the entire WAA, determine if any of the soils in the area being assessed have been altered. In particular, look for evidence of excavation or fill, severe compaction, or other types of impact that significantly alter soil properties. For the purposes of this assessment approach, the presence of a plow layer should not be considered a soil alteration. (Note: the influence of past tilling is accounted for in the assessment of A horizon thickness).

- (2) If no altered soils exist, the percent of the assessment area with altered soils is zero. This indicates that all of the soils in the assessment area are similar to soils in reference standard sites.
- (3) If altered soils exist, estimate the percentage of the assessment area that has soils that have been altered.
- (4) Report the percent of the assessment area with altered soils on Data Form 2 in the box on the right of the  $V_{SOIL}$  row, and transfer that value to the box on the right of the  $V_{SOIL}$  row on Data Form 4.

### **$V_{SSD}$ - Shrub-Sapling Density**

Shrubs and saplings are woody stems less than 10 cm (4 in.) dbh and greater than 1.4 m (4.5 ft) in height. Density of shrub-sapling stems per hectare is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Count woody stems less than 10 cm (4 in.) and greater than 1.4 m (4.5 ft) in height in two 0.004-ha circular subplots (radius 3.6 m or 11.8 ft) nested within the 0.04-ha plot (Figure 30). Record the number of stems in each 0.004-ha subplot in the spaces provided in the  $V_{SSD}$  row on Data Form 3.
- (2) Sum the subplot values and multiply by 125. Enter the result in the right hand block in the  $V_{SSD}$  row on Data Form 3. Transfer this value (stems/ha) to the  $V_{SSD}$  row on Data Form 4.
- (3) Sum the  $V_{SSD}$  plot values on Data Form 4 and enter the result in the right hand block in the  $V_{SSD}$  row on Data Form 4.

### **$V_{STRATA}$ - Number of Vegetation Strata**

The number of vegetation layers (strata) present in a forested wetland reflects the diversity of food, cover, and nest sites available to wildlife, particularly birds, but also to many reptiles, invertebrates, and arboreal mammals. Estimate the vertical complexity of the WAA using the following procedure:

- (1) During a reconnaissance walkover of the entire WAA, identify which of the following vegetation layers are present and account for at least 10 percent cover, on average, throughout the site.
  - Canopy (trees in the canopy layer greater than or equal to 10 cm dbh).
  - Subcanopy (trees below the canopy layer greater than or equal to 10 cm dbh. Recognize this layer if it is distinctly different from a higher, more mature canopy).
  - Understory (shrubs and saplings less than 10 cm dbh but at least 4.5 ft tall).

- Ground cover (woody plants less than 4.5 ft tall and herbaceous vegetation).
- (2) Enter the number of vegetation strata (0 – 4) present in the right-hand block on the  $V_{STRATA}$  row on Data Form 2, and transfer that number to the  $V_{STRATA}$  row on Data Form 4.

### **$V_{TBA}$ - Tree Basal Area**

Trees are defined as living woody stems greater than or equal to 10 cm (4 in) dbh. Tree basal area is a common measure of abundance and dominance in forest ecology that has been shown to be proportional to tree biomass (Bonham 1989; Spurr and Barnes 1981; Tritton and Hornbeck 1982; Whittaker 1975; Whittaker et al. 1974). Tree basal area per hectare is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Use a basal area wedge prism (or other basal area estimation tool) as directed to tally eligible tree stems, and enter the tally in the indicated space on the  $V_{TBA}$  line on Data Form 3. Basal area prisms are available in various Basal Area Factors, and in both SI (metric) and non-SI (English) versions. Some are inappropriate for use in collecting the data needed here, because they are intended to be used for large-diameter trees in areas with little understory. The non-SI 10-factor prism works well in forests of the Delta region, and it is readily available.
- (2) Calculate plot basal area in  $m^2/ha$  by multiplying the tree count by the appropriate conversion factor. For example, when using the non-SI 10-factor prism, multiply the number of stems tallied by 2.3. Enter the total basal area figure in the right-hand box on the  $V_{TBA}$  row on Data Form 3.
- (3) Transfer the total basal area as a plot value to the  $V_{TBA}$  row on Data Form 4. Average all plot basal area values and enter that number in the right-hand box on the  $V_{TBA}$  row on Data Form 4.

An alternative method also is available to directly measure tree diameters in the 0.04-ha plot, rather than use a plotless (e.g., wedge prism) estimation method. The difference between the two methods is likely to be insignificant at the level of resolution employed in the HGM assessment. However, if a wedge prism or similar tool is not available, or if undergrowth is too thick to allow a prism to be used accurately, direct diameter measurement (using a dbh tape or tree caliper) may be the only option available. The direct measurement approach can be used to facilitate more rigorous data collection, particularly if the relative dominance of each tree species is an important consideration. Therefore, an alternative field form is provided in Appendix C1 that can be used to record the species and diameter of every tree within the 0.04-ha plot. Basal area can be calculated by hand on that data form, or on the spreadsheet provided in Appendix D. The spreadsheet will also indicate the basal area of each tree so the individual tree values for each species can be summed to determine the total basal area by species if desired. This can be used simply to provide more detailed

documentation of the assessment process, or to improve the rigor of estimates for the  $V_{TCOMP}$  variable. Tree counts directly from the basal area sheets can also be used instead of the field counts that are the recommended method for deriving the  $V_{TDEN}$  variable.

In general, the recommended field methods are likely to be much faster than the diameter measurement approach, but the outcome of the assessment should not differ significantly regardless of which method is used.

The procedure for using the alternative (direct diameter measurement) method is as follows:

- (1) Using a metric (cm) diameter tape, measure the diameter of all trees (living woody stems greater than or equal to 10 cm (4 in.) at breast height) (dbh) in a circular 0.04-ha plot with a radius of 11.3 m (37 ft). Record each diameter measurement in Column 2 of Data Form C1. Recording the species of each tree (Column 1) is optional, but may be helpful, as described previously.
- (2) A spreadsheet is available (Appendix D1) to complete the calculations in Steps 2–5, or they can be done by hand as follows:
  - (a) Square the dbh measurement for each woody stem and enter that number in Column 3.
  - (b) Convert the squared diameters to square meters per hectare by multiplying by 0.00196. Enter this number in Column 4.
  - (c) Sum all Column 4 numbers to get total basal area ( $m^2 / ha$ ) for the plot. Enter this number as a plot value in the  $V_{TBA}$  row on Data Form 4.
  - (d) Average the plot values on Data Form 4 and record the result in the box on the right-hand side of the  $V_{TBA}$  row.

### **$V_{TCOMP}$ - Tree Composition**

The tree composition variable is intended to represent the pattern of dominance among tree species in the forest canopy.  $V_{TCOMP}$  is calculated if the total canopy cover of trees (living woody stems  $\geq 10$  cm or 4 in. at breast height) within the plot is 20 percent or more. Percent concurrence of the dominant tree species in the assessment area with the species composition of reference wetlands in various conditions is the metric used to quantify this variable. Measure it with the following procedure:

- (1) If the tree stratum has at least 20 percent cover, identify the dominant species (based on cover, or on basal area if dbh measurements are taken) and circle them on Data Form 3 of the appropriate wetland subclass. To identify dominants, apply the 50/20 rule (U.S. Army Corps of Engineers 1992). This requires species to be ranked in descending order

of percent cover, summing relative dominance in descending order until 50 percent is exceeded. Additional species with 20 percent relative dominance should also be included as dominants. Accurate identification of woody species is critical for determining the dominant species in each plot. Sampling during the dormant season may require proficiency in recognizing plant form, bark, and dead or dormant plant parts. Users who do not feel confident in identifying trees and shrubs should get help.

- (2) Calculate percent concurrence using the formula provided on Data Form 3, which weights dominant species based on their likelihood of being dominant in reference stands of varying condition.
- (3) Record the percent concurrence value in the box at the right-hand side of the  $V_{TCOMP}$  row on Data Form 3. Record a zero for any plot having less than 20 percent tree cover.
- (4) Transfer the  $V_{TCOMP}$  plot value to Data Form 4. Average all plot values and enter that number in the right-hand box of the  $V_{TCOMP}$  row.

#### **$V_{TDEN}$ - Tree Density**

Tree density is the number of trees (i.e., living woody stems greater than or equal to 10 cm or 4 in.) per unit area. The density of tree stems per hectare is the metric used to quantify this variable. Measure it using the following procedure:

- (1) Count the number of tree stems within the 0.04-ha plot (note: this is not the same as the stem count taken with the basal area wedge prism to determine  $V_{TBA}$ ). Care should be taken not to err in determining whether or not a tree should be counted. Measure the plot radius to all marginal trees, and include only trees having at least half the stem within the plot. If tree diameters were recorded to calculate basal area, then the number of stems can be counted directly from the supplemental basal area field sheet (Data Form C1, Appendix C).
- (2) Record the stem count on Data Form 3 in the  $V_{TDEN}$  row, and multiply by 25 to calculate stems/ha. Transfer stems/ha as a plot value to the  $V_{TDEN}$  row on Data Form 4.
- (3) Average the plot values on Data Form 4 and record the result in the box on the right-hand side of the  $V_{TDEN}$  row.

#### **$V_{TRACT}$ - Wetland Tract**

This variable is defined as the area of contiguous forested wetland that includes the WAA (Figure 25). Adjacent wetlands need not be in the same regional subclass as the assessment area to be part of the wetland tract.

Determine the size of the wetland tract using the following procedure:



- (1) Determine the size of the forested wetland area in hectares that is contiguous and directly accessible to wildlife utilizing the WAA (including the WAA itself). Use topographic maps, aerial photography, GIS, field reconnaissance or another appropriate method.
- (2) Record the forested wetland area in hectares on Data Form 1 in the box at the right-hand side of the  $V_{TRACT}$  row. Transfer this number to the  $V_{TRACT}$  box on Data Form 4.

### **$V_{WD}$ - Woody Debris Biomass and $V_{LOG}$ - Log Biomass**

Woody debris is an important habitat and nutrient cycling component of forests. Volume of woody debris and log biomass per hectare are the metrics used to quantify these variables. Measure them with the following procedure (Brown 1974; Brown et al. 1982).

(Note: all stem diameter criteria and measurements for all size classes refer to diameter at the point of intersection with the transect line. Leaning dead stems that intersect the sampling plane are sampled. Dead trees and shrubs still supported by their roots are not sampled. Rooted stumps are not sampled, but uprooted stumps are sampled. Down stems that are decomposed to the point where they no longer maintain their shape but spread out on the ground are not sampled.)

- (1) Lay out two 15.24-m (50-ft) east-west transects, originating at the 0.04-ha plot center point (Figure 23).
- (2) Count the number of nonliving stems in Size Class 1 (small) (greater than or equal to 0.6 and less than 2.5 cm or greater than or equal to 0.25 and less than 1 in.) that intersect a vertical plane above a 2-m (6-ft) segment of each 15.24-m (50-ft) transect. This can be any 2-m (6-ft) segment, as long as it is consistently placed. Figure 30 illustrates it as placed at the end furthest from the plot center point. Record the number of Size Class 1 stems from each transect in the spaces provided on the  $V_{WD}$  (Size Class 1) line on Data Form 3.
- (3) Count the number of nonliving stems in Size Class 2 (medium) (greater than or equal to 2.5 cm and less than 7.6 cm or greater than or equal to 1 in. and less than 3 in.) that intersect the plane above a 3.7-m (12-ft) segment of each 15.24-m (50-ft) transect. This can be any 3.7-m (12-ft) segment, as long as it is consistently placed. Figure 30 illustrates it as placed at the end furthest from the plot center point, overlapping with the 2-m (6-ft) transect segment. Record the number of Size Class 2 stems from each transect in the spaces provided on the  $V_{WD}$  (Size Class 2) line on Data Form 3.
- (4) Measure and record the diameter of nonliving stems in Size Class 3 (large) (greater than or equal to 7.6 cm ( $\geq 3$  in.)) that intersect the plane above the entire length of the 15.24-m (50-ft) transect. Record the diameter of individual stems (in centimeters) in Size Class 3 from each

transect in the spaces provided on the  $V_{LOG}$  and  $V_{WD}$  (Size Class 3) line on Data Form 3.

- (5) Use the spreadsheet in Figure D2 to convert the stem tallies and diameter measurements to woody debris and log volume ( $m^3/ha$ ) and transfer the resulting values as plot values on the  $V_{LOG}$  and  $V_{WD}$  rows on Data Form 4. Average all plot values, and enter them in the right-hand blocks on the  $V_{LOG}$  and  $V_{WD}$  rows on Data Form 4.

Alternative:

Data Form C1 is an alternative field and calculation form that allows  $V_{LOG}$  and  $V_{WD}$  to be calculated by hand if the user does not wish to use the spreadsheet. Transfer the resulting plot values to the  $V_{LOG}$  and  $V_{WD}$  rows on Data Form 4. Average all plot values, and enter them in the right-hand blocks on the  $V_{LOG}$  and  $V_{WD}$  rows on Data Form 4.

## Analyze Field Data

The analysis of field data requires three steps. The first step is to transform the measure of each assessment variable into a variable subindex. This can be done manually by comparing the summary data (right hand boxes) from Data Form 4 to the graphs at the end of Chapter 5. The second step is to insert the variable subindices into the appropriate assessment models in Chapter 5 and calculate the FCI for each assessed function. Finally, the FCI is multiplied by the area in hectares of the WAA to calculate FCUs for each assessed function. However, all of these calculations can be carried out automatically by entering the Data Form 4 summary data (right-hand boxes) and the area in hectares of the WAA into the spreadsheet workbook provided in Appendix D3. Note that the workbook includes multiple spreadsheets (i.e., pages), so be sure to use the correct spreadsheet for the wetland subclass being assessed (see the tabs at the bottom of the window). Also note that the depression subclasses offer the choice of two spreadsheets: one for noninundated conditions and a simpler version for situations where ground-level variables are not assessed due to standing water. Use the spreadsheet for inundated conditions if any of the plots are under water. Alternatively, separate WAAs can be established for inundated and noninundated subsections of the depression.

When using the spreadsheet in Figure D3, be sure first to clear any values in the "Metric Values" column (shaded green) and to fill out the green-shaded boxes completely to identify the project and the WAA, and to specify the size in hectares of the WAA. Do not attempt to clear or enter data into any nonshaded boxes – the spreadsheet will not accept direct changes to those cells.

After all summary data and the area of the WAA are entered into the spreadsheet, the FCI and FCU values for each assessed function are displayed at the bottom of the spreadsheet.

## Document Assessment Results

Once all of the data collection, summarization, and analysis steps have been completed, it is important to assemble all pertinent documentation. Appendix A2 is a cover sheet that, when completed, identifies the assembled maps, drawings, project description, data forms, and summary sheets (including spreadsheet printouts) that are attached to document the assessment. It is highly recommended that this documentation step be completed.

## Apply Assessment Results

Once the assessment and analysis phases are complete, the results can be used to compare the same WAA at different points in time, compare different WAAs at the same point in time, or compare different alternatives to a project. The basic unit of comparison is the FCU, but it is often helpful to examine specific impacts and mitigation actions by examining their effects on the FCI independent of the area affected. The FCI/FCU spreadsheets are particularly useful tools for testing various scenarios and proposed actions — they allow experimentation with various alternative actions and areas affected to help isolate the project options with the least impact or the most effective restoration or mitigation approaches.

Note that the assessment procedure does not produce a single grand index of function — rather each function is separately assessed and scored, resulting in a set of functional index scores and functional units. How these are used in any particular analysis depends on the objectives of the analysis. In the case of an impact assessment, it may be reasonable to focus on the function that is most detrimentally affected. In cases where certain resources are particular regional priorities, the assessment may tend to focus on the functions most directly associated with those resources. For example, wildlife functions may be particularly important in an area that has been extensively converted to agriculture. Hydrologic functions may be of greatest interest if the project being assessed will alter water storage or flooding patterns. Conversely, this type of analysis can help to recognize when a particular function is being maximized to the detriment of other functions, as might occur where a wetland is created as part of a stormwater facility; vegetation composition and structure, detritus accumulation, and other variables in such a setting would likely demonstrate that some functions are maintained at very low levels, while hydrologic functions are maximized.

Generally, comparisons can be made only between wetlands or alternatives that involve the same wetland subclass, although comparisons between subclasses can be made on the basis of functions performed rather than the magnitude of functional performance. For example, riverine subclasses have import and export functions that are not present in flats or isolated depressions. Conversely, isolated depressions are more likely to support endemic species than are river-connected systems. These types of comparisons may be particularly important where a proposed action will result in a change of subclass. When a levee, for example, will convert a riverine wetland to a flat, it is helpful to be able to recognize that certain import and export functions will no longer occur.

Users of this guidebook must recognize that not all situations can be anticipated or accounted for in developing a rapid assessment method. In particular, users must be able to adapt the material presented here to special or unique situations encountered in the field. For example, most of the reference standard conditions identified in the field were mature forests with high species diversity, and typically the riverine and flats subclasses were dominated by a variety of oak species while the depressional subclasses were dominated by baldcypress and overcup oak. Sites that deviate from these reference conditions may produce low scores for some functions. However, there are situations where deviation from the reference standard condition is appropriate, and should be recognized as such. In most of these cases, alternative reference standards have been identified in the discussions of assessment variables (e.g., cottonwood or willow dominating on new substrates is recognized as an appropriate  $V_{COMP}$  condition). In other instances, however, professional judgment in the field is essential to proper application of the models. For example, some depression sites with near-permanent flooding are dominated by buttonbush. Where this occurs because of water control structures or impeded drainage due to roads, it should be recognized as having arrested functional status, at least for some functions. However, where the same situation occurs because of beaver activity or changes in channel courses, the buttonbush swamp should be recognized as a functional component of a larger wetland complex, and the  $V_{COMP}$  weighting system can be adjusted accordingly. Another potential way to deal with beaver in the modern landscape is to adopt the perspective that beaver complexes are fully functional but transient components of riverine wetland systems for all functions. At the same time, if beaver are not present (even in an area where they would normally be expected to occur), the resulting riverine wetland can be assessed using the models, but the overall WAA is not penalized either way. Other situations that require special consideration include areas affected by fire, sites damaged by ice storms, and similar occurrences. Note however, that normal, noncatastrophic disturbances to wetlands (i.e., tree mortality causing small openings) are accounted for in the reference data used in this guidebook.

Because the HGM models are calibrated with reference to mature, complex plant communities, and the wildlife habitat models emphasize the requirements of species needing large, contiguous blocks of habitat, early successional wetlands in fragmented landscapes will receive very low assessment scores for the wildlife habitat function. In such situations, it may be useful to supplement the wildlife habitat assessment models with alternative methods such as the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980). This approach can provide a more sensitive assessment of the early developmental period following wetland restoration or changes in management than the HGM models presented here.

Another potential consideration in the application of the assessment models presented here concerns the projection of future conditions. This may be particularly important in determining the rate at which functional status will improve as a result of restoration actions intended to offset impacts to jurisdictional wetlands. The graphs in Figure 31 represent general recovery trajectories for forested sites within the Delta Region of Arkansas based on a subset of the reference data collected to develop this guidebook. In selected stands, individual trees were aged using an increment corer to develop a general relationship between the age

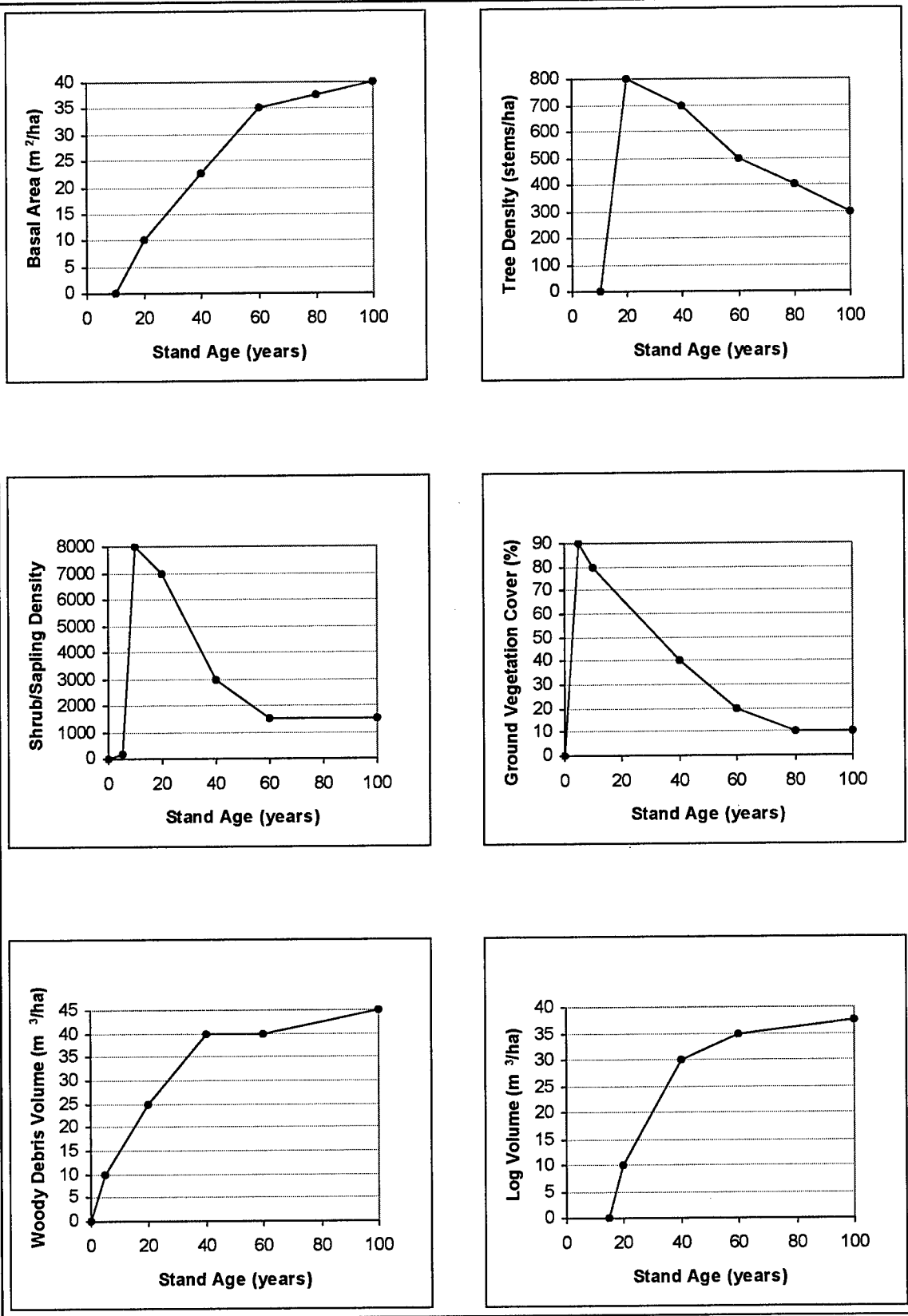


Figure 31. Projected recovery trajectories for selected assessment variables (Continued)

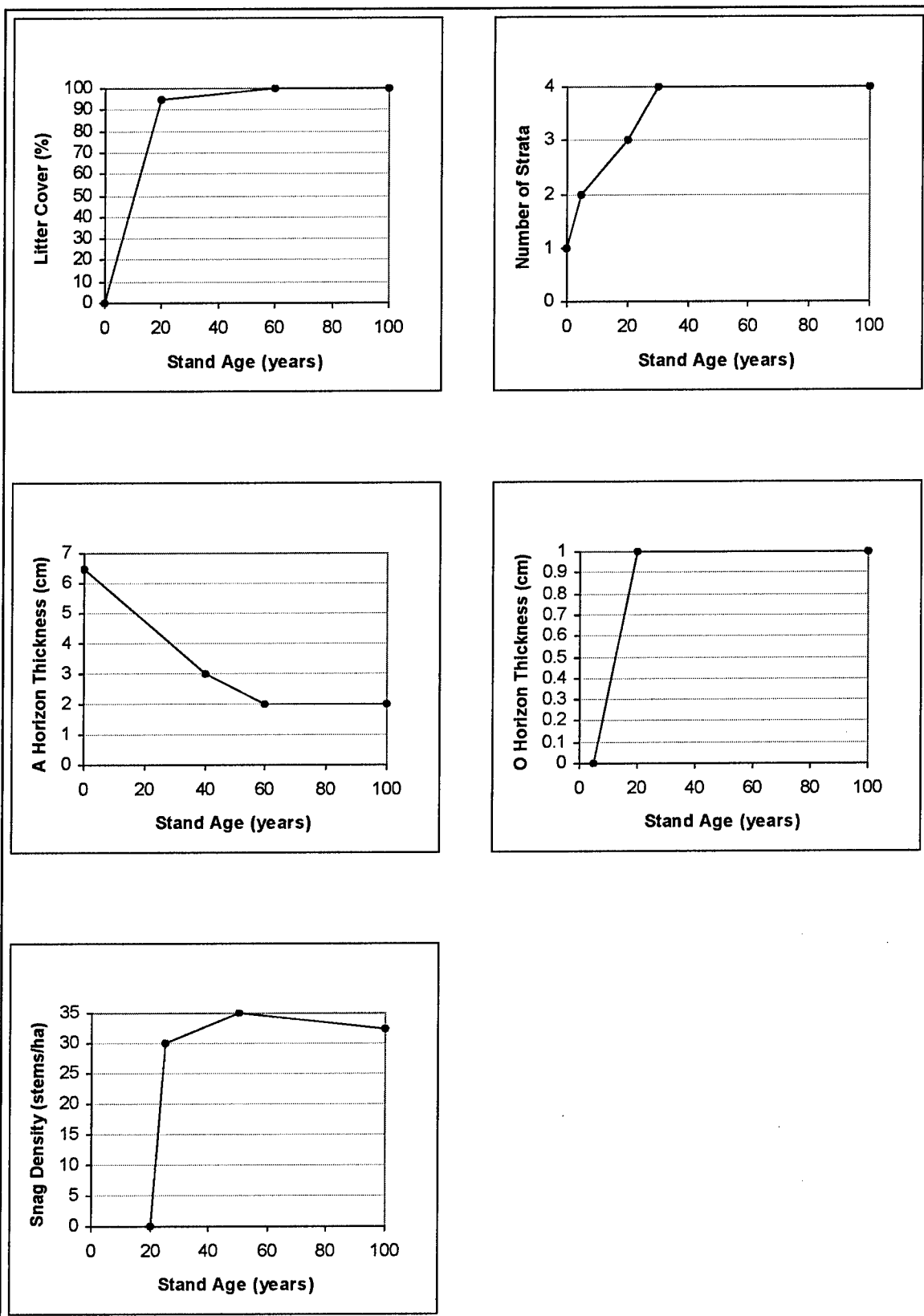


Figure 31. (Concluded)

of sampled stands and the site-specific variables employed in the assessment models. Thus, a user can estimate the overstory basal area, shrub density, woody debris volume, and other functional indicators for various time intervals, and calculate functional capacity indices for all assessed functions. These curves are specifically constructed to reflect wetland recovery following restoration of agricultural land, which is the most common restoration scenario in the Delta Region of Arkansas. Therefore, they assume that the initial site condition includes bare ground that has been tilled (hence the deeper initial apparent A horizon). Note that landscape variables are not included here, because they require site-specific knowledge to project future conditions. However, it is also important to carefully consider the changing nature of the block size and connectivity variables used in the HGM models as the site matures. The spatial habitat variables ( $V_{TRACT}$ ,  $V_{SCORE}$ , and  $V_{CONNECT}$ ) are focused to a great extent on vegetation structure as it provides concealment and movement corridors. Thus, a wetland isolated from nearby forests at the initial assessment may be fully connected within a decade or two if the intervening fields have been allowed to grow into scrub and young forest habitats.

Ponding development rates also are not estimated, because ponding is the result of both geomorphic and biotic factors, and the initial site conditions (i.e., extent of land leveling). The degree of microtopographic relief will be dependent on the extent of site contouring work done prior to planting in most cases. Similarly, the rates of compositional change ( $V_{COMP}$  and  $V_{TCOMP}$ ) are dependent on initial site conditions; generally, a site planted with appropriate species should have an FCI score of 1.0 soon after planting for the compositional variable  $V_{COMP}$ , and maintain that fully functional status indefinitely as  $V_{TCOMP}$  becomes the applicable compositional variable. Estimation of future composition for unplanted areas will require site-specific evaluation of seed sources and probable colonization patterns.

Note also that the graphs in Figure 31 are amalgams of data from all wetland subclasses. In situations where a site is expected to be unusual in one or more respects (such as a cottonwood stand, where basal areas are likely to increase more quickly than in hardwood forests), more specific data may exist, and should be substituted for these general curves as appropriate.

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# **Appendix A Preliminary Project Documentation and Field Sampling Guidance**

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## **CONTENTS**

- Appendix A1     Site or Project Information and Assessment Documentation
- Appendix A2     Field Assessment Preparation Checklist Including List  
                         of Data Forms
- Appendix A3     Layout of Plots and Transects for Field Sampling

Please reproduce these forms as needed.

## APPENDIX A1

### SITE or PROJECT INFORMATION and ASSESSMENT DOCUMENTATION

(Complete one form for entire site or project area)

Date: \_\_\_\_\_

Project/Site Name: \_\_\_\_\_

Person(s) involved in assessment:

Field \_\_\_\_\_

Computations/summarization/quality control \_\_\_\_\_

The following checked items are attached:

\_\_\_\_\_ A description of the project, including land ownership, baseline conditions, proposed actions, purpose, project proponent, regulatory or other context, and reviewing agencies.

\_\_\_\_\_ Maps, aerial photos, and /or drawings of the project area, showing boundaries and identifying labels of Wetland Assessment Areas and project features.

\_\_\_\_\_ Other pertinent documentation (describe): \_\_\_\_\_

\_\_\_\_\_ Field Data Forms and assessment summaries (listed in table below):

Wetland Assessment Area (WAA) ID Number	HGM Subclass	WAA Size (ha)	Number of plots sampled	Attached Data Forms and Summary Forms				
				Data Forms (number attached)				FCI/FCU Summaries (Spreadsheet D3 printouts or hand calculations)
				Form 1	Form 2	Form 3	Form 4	

Alternative Field and Summarization Forms Attached:

\_\_\_\_\_ Basal Area (DATA FORM C1)

\_\_\_\_\_ Log and Woody Debris (DATA FORM C2)

## APPENDIX A2

### FIELD ASSESSMENT PREPARATION CHECKLIST

Prior to conducting field studies, review the checklist below to determine what field gear will be required, and how many copies of each data form will be needed. It may be helpful to complete as much of the Site or Project Information and Assessment Documentation (Data Form A1) as possible prior to going to the field. For large or complex assessment areas, that Form should be completed as part of a reconnaissance study to classify and map all of the Wetland Assessment Areas within the project area or site boundary.

FIELD GEAR REQUIRED	COMMENTS
DISTANCE TAPE (preferably metric, at least 50 ft or 20 m) AND ANCHOR PIN	Minimum of 1, but 2 will speed work if enough people are available to record different information independently. A survey pin is handy to mark the plot center and anchor the tape for woody debris transects and for determining plot boundaries.
FOLDING RULE	A folding rule, small tape, or dbh caliper suitable for measuring the diameter of logs is needed.
PLANT IDENTIFICATION MANUALS	At least one person on the assessment team must be able to readily and reliably identify woody species, but field guides are recommended as part of the assessment tool kit. If species of concern, threatened, or endangered species are potentially present, the assessment team should include a botanist who can recognize them.
PLOT LAYOUT DIAGRAM	A copy is attached to this checklist.
DATA FORMS	See data forms, next page.
BASAL AREA PRISM OR DBH TAPE OR SUITABLE SUBSTITUTE	A 10-factor English unit wedge prism (available from forestry equipment supply companies) is the recommended tool for quickly determining tree basal area. Other tools may be substituted if they provide comparable data. Guidelines for the use of the wedge prism are attached to this checklist. If using a dbh tape or caliper, note that you will need the supplemental field data form for recording diameter measurements (Alternate Data Form C1).
SOIL SURVEY	Optional, but may be helpful in evaluating soil-related variables.
HGM GUIDEBOOK (this report)	At minimum, Chapter 6 should be available in the field to consult regarding field methods. All assessment team members should be familiar with the entire guidebook prior to fieldwork.
SHOVEL OR HEAVY-DUTY TROWEL	If heavy or hard soils are anticipated, a shovel will be necessary. You need to be able to dig at least 10 inches deep. A water bottle is recommended if conditions are dry, to help distinguish soil colors (organic-stained soils must be distinguished from mineral soil).
MISCELLANEOUS SUGGESTED GEAR	You'll need clipboards and pencils, and extra data forms are highly recommended. Flagging may be helpful for establishing plot centers and boundaries, at least until the assessment team is comfortable with the field procedures. A camera and GPS unit will improve documentation of the assessment and are highly recommended. Record position and take a representative photo at each plot location. Field copies of aerial photos and topo maps may be important if multiple Wetland Assessment Areas must be established and recognized in the field.

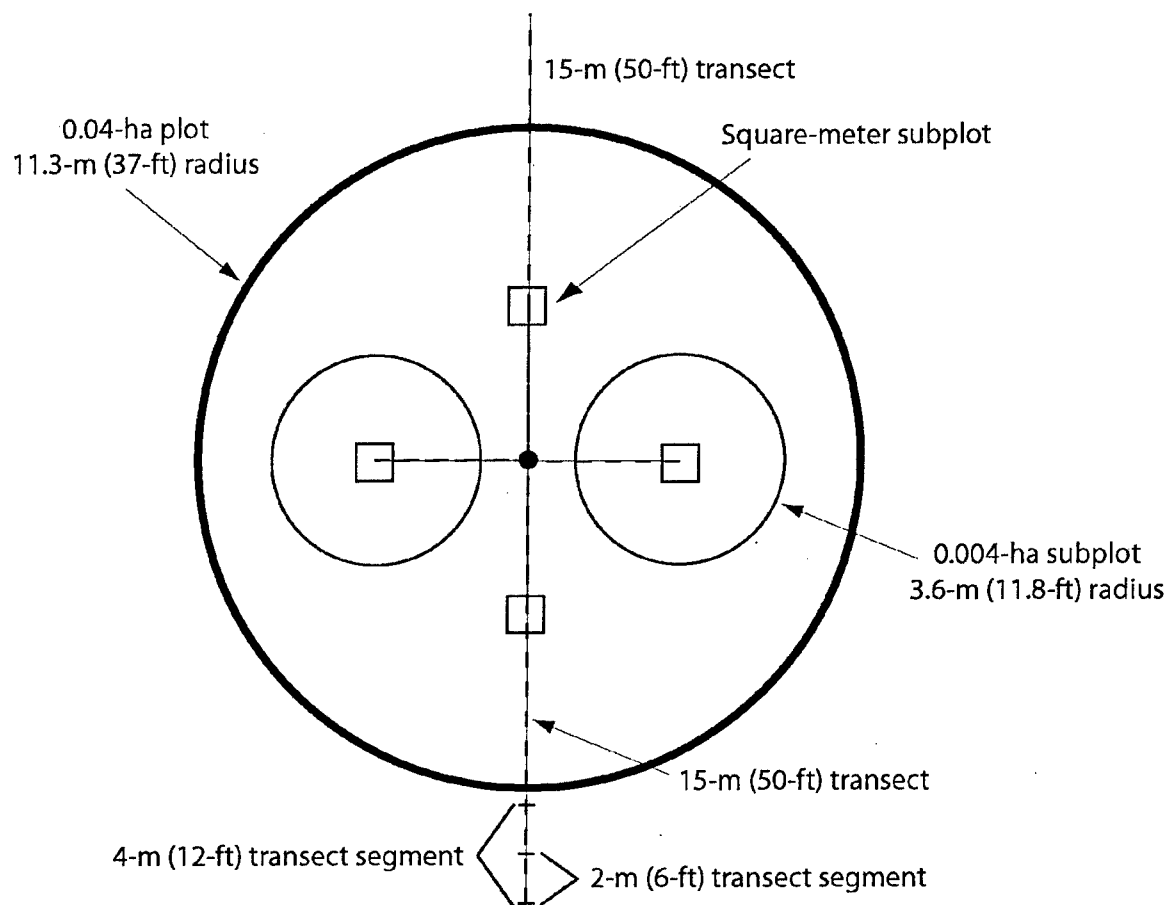
## APPENDIX A2

### DATA FORMS

Print the following data forms (found in Appendix B) in the numbers indicated. (Extras are always a good idea.) Be sure to use the forms developed specifically for the wetland subclass(es) you are assessing.

DATA FORM	Number of Copies Required
<b>Data Form A1, Site or Project Information and Assessment Documentation</b> (1 page)	1
<b>Data Form 1 - Tract - Level Data Collection</b> (1 page) (Complete using maps, photos, hydrologic data etc.)	1 per Wetland Assessment Area
<b>Data Form 2 – Wetland Assessment Area – Level Data Collection</b> (1 page) (Complete based on field reconnaissance)	1 per Wetland Assessment Area
<b>Data Form 3 - Plot-Level Data Collection</b> (3 pages per set) (Complete by sampling within nested circular plots and along transects)	Multiple sets, depending on size, variability, and number of Wetland Assessment Areas (see Chapter 6)
<b>Data Form 4 – Wetland Assessment Area Data Summary</b> (1 page) (Use to compile data from Forms 1, 2, and 3 prior to entering in spreadsheet or manually calculating FCI and FCU.)	1 per Wetland Assessment Area
<b>OPTIONAL:</b> <b>Alternate Basal Area Field and Calculation Form</b> (1 page) (Use if sampling with a dbh tape or caliper (rather than prism); This is Alternate Data Form C1, Appendix C)	Multiple copies (same number as Data Form 3 sets)

## APPENDIX A3



**Layout of Plots and Transects for Field Sampling**

# Appendix B

## Field Data Forms

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### CONTENTS

Appendix B1	Non-Alkali Flat Wetlands
Appendix B2	Low-Gradient Riverine Backwater Wetlands
Appendix B3	Low- Gradient Riverine Overbank Wetlands
Appendix B4	Headwater Depression Wetlands
Appendix B5	Isolated Depression Wetlands
Appendix B6	Connected Depression Wetlands

## Appendix B1

### Field Data Forms for Non-Alkali Flat Wetlands

<b>Data Form</b>	<b>Number of Pages</b>	<b>Title</b>
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION**

**SUBCLASS: NON-ALKALI FLAT WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps and field reconnaissance as necessary to complete this sheet.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____ %
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____ %
Geomorphic surface (used to determine appropriate $V_{POND}$ entry on spreadsheet)	<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <b>CHECK ONE:</b> </div> <div style="width: 60%;"> <div>Pleistocene Alluvial Terrace (map codes beginning with Pt, Pd, Pi, Pp, Qt) _____</div> <div>Pleistocene Valley Train (map codes beginning with Pv) _____</div> <div>Holocene Alluvium (map codes beginning with H) _____</div> </div> </div>	



**DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION**

**SUBCLASS: NON-ALKALI FLAT WETLANDS**

**WAA #** \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Walk the entire Assessment Area and develop estimates of the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

<b>HGM Variable Addressed</b>	<b>Procedure (see Chapter 6 for details)</b>	<b>Indicator Value</b>
$V_{POND}$ Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _____
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = _____
$V_{SOIL}$ Soil integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: NON-ALKALI FLAT WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	<p>Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m<sup>2</sup>/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).</p> <p><b>Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.</b></p>	<p>Number of stems tallied = _____</p> <p>x conversion factor = _____</p>	<p>Total basal area = _____ m<sup>2</sup>/ha</p>

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____ _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____	Average thickness of A horizon = _____ cm

### DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION

**SUBCLASS: NON-ALKALI FLAT WETLANDS**

WAA # \_\_\_\_\_

**PLOT #** \_\_\_\_\_

## OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
(1) If tree cover is $\geq 20\%$ , use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
(2) If tree cover is $< 20\%$ , identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.		
<b>A: Common dominants in reference standard sites</b>	<b>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</b>	<b>C: Uncommon, minor, or shrub species in reference standard sites, but may dominate in severely damaged systems</b>
<i>Carya ovata</i>	<i>Acer negundo</i>	<i>Carpinus caroliniana</i>
<i>Pinus taeda</i>	<i>Carya aquatica</i>	<i>Cornus foemina</i>
<i>Quercus lyrata</i>	<i>Carya illinoensis</i>	<i>Crataegus</i> spp.
<i>Quercus michauxii</i>	<i>Celtis laevigata</i>	<i>Forestiera acuminata</i>
<i>Quercus nigra</i>	<i>Diospyros virginiana</i>	<i>Gleditsia triacanthos</i>
<i>Quercus nuttallii</i>	<i>Fraxinus pennsylvanica</i>	<i>Machura pomifera</i>
<i>Quercus pagoda</i>	<i>Liquidambar styraciflua</i>	<i>Morus rubra</i>
<i>Quercus phellos</i>	<i>Platanus occidentalis</i>	<i>Ulmus crassifolia</i>
<i>Quercus stellata</i>	<i>Populus deltoides</i>	<i>Ulmus alata</i>
	<i>Quercus falcata</i>	
	<i>Ulmus americana</i>	
Calculations		
Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula:		
$\{[(1.0 * \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B}) + (0.33 * \text{number of circled dominants in Column C})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%$		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TCOMP}$ $V_{COMP}$ Composition of woody vegetation strata	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p style="text-align: center;"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	Percent concurrence:  $V_{TCOMP} = \underline{\hspace{2cm}} \%$ $V_{COMP} = \underline{\hspace{2cm}} \%$

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: NON-ALKALI FLAT WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

## **OBSERVATIONS WITHIN TWO 0.004-HA PLOTS**

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ $\times 125 =$ _____	Understory stems/ha = _____

## **OBSERVATIONS WITHIN 4 SUBPLOTS 1 m $\times$ 1 m SQUARE**

From the center point, measure 5 m in each cardinal direction and establish a 1-m  $\times$  1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

## **OBSERVATIONS ALONG TRANSECTS**

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, _____, _____, _____
	Transect 2	_____, _____, _____, _____

# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: NON-ALKALI FLAT WETLANDS**

**WAA #** \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	Transfer the data below from Data Form 1								Enter this number in the FCI calculator spreadsheet		
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA								_____ ha		
$V_{CORE}$	Size of wetland tract that is core area								_____ %		
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"								_____ %		
<b>Transfer the data below from Data Form 2</b>											
$V_{POND}$	Percent of the wetland assessment area that ponds water								_____ %		
Geomorphic surface (used to determine appropriate $V_{POND}$ entry on spreadsheet - from Data Form 1)				CHECK ONE:		Pleistocene Alluvial Terrace _____ Pleistocene Valley Train _____ Holocene Alluvium _____					
$V_{STRATA}$	Number of vegetation strata								_____ strata		
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils								_____ %		
<b>Transfer the plot data below from Data Form 3 and average all values</b>											
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>		
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha		
$V_{TDEN}$									density = _____ stems/ha		
$V_{SNAG}$									density = _____ stems/ha		
$V_{TCOMP}$									concurrence = _____ %		
$V_{COMP}$									concurrence = _____ %		
$V_{SSD}$									density = _____ stems/ha		
$V_{GVC}$									cover = _____ %		
$V_{LITTER}$									cover = _____ %		
$V_{OHOR}$									thickness = _____ cm		
$V_{AHOR}$									thickness = _____ cm		
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>											
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha		
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha		

## Appendix B2

### Field Data Forms for Low-Gradient Riverine Backwater Wetlands

Data Form	Number of Pages	Title
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION**

**SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps and field reconnaissance as necessary to complete this sheet.

<b>HGM Variable Addressed</b>	<b>Procedure (see Chapter 6 for details)</b>	<b>Indicator Value</b>
$V_{FREQ}$ Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____%
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____%

# DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION

## SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS

WAA # \_\_\_\_\_

### Complete one copy of this form for each Wetland Assessment Area

Walk the entire Assessment Area and develop estimates of the following indicators. For large or highly variable Assessment Areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{POND}$ Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond =
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present =
$V_{SOIL}$ Soil integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils =
$V_{CEC}$ Cation Exchange Capacity (CEC)	For each altered area in the assessment area, determine the change in CEC and the area affected using the worksheet below. Base your estimates of CEC on the soil survey and/or the information in the table below (generally, use the midpoint of the CEC range - assume zero CEC for compacted areas such as roads). Record the summed results (from column 5, below) as a percentage indicating relative CEC change in the space at right.	Percentage change in CEC = _____%

CEC Worksheet	<u>Col. 1</u> CEC after alteration	<u>Col. 2</u> CEC before alteration	<u>Col. 3</u> Absolute Value of Col. 1 minus Col. 2	<u>Col. 4</u> % of assessment area	<u>Col. 5</u> Multiply Col. 3 $\times$ Col. 4
Altered Area 1					
Altered Area 2					
Altered Area 3					
SUM=					

### CEC Reference Table

Predominant Soil Texture or Map Unit Symbol	CEC Range (meq / 100 grams)	Midpoint of CEC Range (meq / 100 grams)
Sand	1-5	2.5
Fine Sandy Loam	5-10	7.5
Loam	5-15	10
Silt Loam	5-15	10
Clay Loam	15-30	22.5
Clay	30-150	90
Add other texture classes / map units		



# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	<p>Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in <math>m^2/ha</math> using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).</p> <p><b>Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.</b></p>	<p>Number of stems tallied = _____</p> <p>x conversion factor = _____</p>	<p>Total basal area = _____ <math>m^2/ha</math></p>

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh $\geq$ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh $\geq$ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____ _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____ _____	Average thickness of A horizon = _____ cm

**DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

**SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

**OBSERVATIONS WITHIN A 0.04-HA PLOT**

Field Procedure		
<p>(1) If tree cover is <math>\geq 20\%</math>, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p>(2) If tree cover is <math>&lt; 20\%</math>, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p><b>A: Common dominants in reference standard sites</b></p>	<p><b>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</b></p>	<p><b>C: Uncommon, minor, or shrub species in reference standard sites, but may dominate in severely damaged systems</b></p>
<i>Carya aquatica</i>	<i>Acer drummondii</i>	<i>Carpinus caroliniana</i>
<i>Quercus lyrata</i>	<i>Acer negundo</i>	<i>Cornus drummondii</i>
<i>Quercus muhlenbergii</i>	<i>Acer rubrum</i>	<i>Cornus foemina</i>
<i>Quercus phellos</i>	<i>Carya illinoensis</i>	<i>Crataegus</i> spp.
	<i>Celtis laevigata</i>	<i>Forestiera acuminata</i>
	<i>Diospyros virginiana</i>	<i>Ilex deciduas</i>
	<i>Fraxinus pennsylvanica</i>	<i>Planera aquatica</i>
	<i>Gleditsia aquatica</i>	
	<i>Liquidambar styraciflua</i>	
	<i>Salix nigra</i>	
	<i>Ulmus americana</i>	
	<i>Ulmus crassifolia</i>	
Calculations		
<p>Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula:</p> <p><math>\{[(1.0 * \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B}) + (0.33 * \text{number of circled dominants in Column C})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%</math></p>		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TCOMP}$ $V_{COMP}$ Composition of woody vegetation strata	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p align="center"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	<p>Percent concurrence:</p> <p><math>V_{TCOMP} = \underline{\hspace{2cm}} \%</math></p> <p><math>V_{COMP} = \underline{\hspace{2cm}} \%</math></p>

### DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION

#### SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

#### OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/Sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ $\times 125 =$ _____	Understory stems/ha = _____

#### OBSERVATIONS WITHIN 4 SUBPLOTS 1 m $\times$ 1 m SQUARE

From the center point, measure 5 m in each cardinal direction and establish a 1-m  $\times$  1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

#### OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, _____, _____, _____
	Transect 2	_____, _____, _____, _____

# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: LOW-GRADIENT RIVERINE BACKWATER WETLANDS**

**WAA #** \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	Transfer the data below from Data Form 1	Enter this number in the FCI calculator spreadsheet							
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA	_____ ha							
$V_{CORE}$	Size of wetland tract that is core area	_____ %							
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"	_____ %							
$V_{FREQ}$	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)	_____							
<b>Transfer the data below from Data Form 2</b>									
$V_{POND}$	Percent of the wetland assessment area that ponds water	_____ %							
$V_{STRATA}$	Number of vegetation strata	_____ strata							
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils	_____ %							
$V_{CEC}$	Percent difference in CEC in WAA (from Data Form 2)	_____ %							
<b>Transfer the plot data below from Data Form 3 and average all values</b>									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha
$V_{TDEN}$									density = _____ stems/ha
$V_{SNAG}$									density = _____ stems/ha
$V_{TCOMP}$									concurrence = _____ %
$V_{COMP}$									concurrence = _____ %
$V_{SSD}$									density = _____ stems/ha
$V_{GVC}$									cover = _____ %
$V_{LITTER}$									cover = _____ %
$V_{OHOR}$									thickness = _____ cm
$V_{AHOR}$									thickness = _____ cm
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>									
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha

## Appendix B3

### Field Data Forms for Low-Gradient Riverine Overbank Wetlands

Data Form	Number of Pages	Title
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION**

**SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

**WAA #** \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps and field reconnaissance as necessary to complete this sheet.

<b>HGM Variable Addressed</b>	<b>Procedure (see Chapter 6 for details)</b>	<b>Indicator Value</b>
$V_{FREQ}$ Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____ %
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____ %

**DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION**

**SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Walk the entire assessment area and develop estimates of the following indicators. For large or highly variable assessment areas, establish a series of transects across the area and make estimates along each transect, then average them for the area.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{POND}$ Percentage of the site capable of ponding water	Estimate the area likely to be ponded following extended rainfall. This includes both large vernal pool sites (swales) and microdepressions such as those left by trees that have blown over and uprooted.	% of site likely to pond = _____
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = _____
$V_{SOIL}$ Soil integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____
$V_{CEC}$ Cation Exchange Capacity (CEC)	For each altered area in the assessment area, determine the change in CEC and the area affected using the worksheet below. Base your estimates of CEC on the soil survey and/or the information in the table below (generally, use the midpoint of the CEC range - assume zero CEC for compacted areas such as roads). Record the summed results (from column 5, below) as a percentage indicating relative CEC change in the space at right.	Percentage change in CEC = _____%

CEC Worksheet	<u>Col. 1</u> CEC after alteration	<u>Col. 2</u> CEC before alteration	<u>Col. 3</u> Absolute Value of Col. 1 minus Col. 2	<u>Col. 4</u> % of assessment area	<u>Col. 5</u> Multiply Col. 3 $\times$ Col. 4
Altered Area 1					
Altered Area 2					
Altered Area 3					
SUM=					

**CEC Reference Table**

Predominant Soil Texture or Map Unit Symbol	CEC Range (meq / 100 grams)	Midpoint of CEC Range (meq / 100 grams)
Sand	1-5	2.5
Fine Sandy Loam	5-10	7.5
Loam	5-15	10
Silt Loam	5-15	10
Clay Loam	15-30	22.5
Clay	30-150	90
Add other texture classes / map units		

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly spaced transects.

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	<p>Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m<sup>2</sup>/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).</p> <p><b>Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.</b></p>	<p>Number of stems tallied = _____</p> <p>x conversion factor = _____</p>	<p>Total basal area = _____ m<sup>2</sup>/ha</p>

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____ _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____ _____	Average thickness of A horizon = _____ cm



**DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

**SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

WAA # \_\_\_\_\_

**PLOT #** \_\_\_\_\_

## OBSERVATIONS WITHIN A 0.04-HA PLOT

Field Procedure		
<p>(1) If tree cover is <math>\geq 20\%</math>, use the 50/20 rule and circle the dominant trees in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p>(2) If tree cover is <math>&lt; 20\%</math>, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A, B, and C below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<b>A:</b> Common dominants in reference standard sites	<b>B:</b> Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances	<b>C:</b> Uncommon, minor, or shrub species in reference standard sites, but may dominate in severely damaged systems
<i>Carya aquatica</i>	<i>Acer rubrum</i>	<i>Acer negundo</i>
<i>Carya illinoensis</i>	<i>Acer saccharinum</i>	<i>Carpinus caroliniana</i>
<i>Gleditsia aquatica</i>	<i>Celtis laevigata</i>	<i>Crataegus</i> spp.
<i>Platanus occidentalis</i>	<i>Diospyros virginiana</i>	<i>Forestiera acuminata</i>
<i>Populus deltoides</i>	<i>Fraxinus pennsylvanica</i>	<i>Morus rubra</i>
<i>Quercus lyrata</i>	<i>Liquidambar styraciflua</i>	<i>Planera aquatica</i>
<i>Quercus muhlenbergii</i>	<i>Quercus nigra</i>	<i>Ulmus crassifolia</i>
<i>Quercus pagoda</i>	<i>Ulmus americana</i>	
<i>Quercus phellos</i>		
<i>Salix</i> spp.		
<i>Taxodium distichum</i>		
Calculations		
<p>Using the dominant species circled in Columns A, B, and C above, calculate percent concurrence according to the following formula:</p> $\{[(1.0 * \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B}) + (0.33 * \text{number of circled dominants in Column C})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%$		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TCOMP}$ $V_{COMP}$ Composition of woody vegetation strata	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p style="text-align: center;"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	<p>Percent concurrence:</p> $V_{TCOMP} = \underline{\hspace{2cm}} \%$ $V_{COMP} = \underline{\hspace{2cm}} \%$

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **OBSERVATIONS WITHIN TWO 0.004-HA PLOTS**

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ $\times 125 =$ _____	Understory stems/ha = _____

### **OBSERVATIONS WITHIN 4 SUBPLOTS 1 m $\times$ 1 m SQUARE**

From the center point, measure 5m in each cardinal direction and establish a 1-m  $\times$  1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

### **OBSERVATIONS ALONG TRANSECTS**

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____
	Transect 2	_____

# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: LOW-GRADIENT RIVERINE OVERBANK WETLANDS**

**WAA #** \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5.

HGM Variable	Transfer the data below from Data Form 1								Enter this number in the FCI calculator spreadsheet
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA								_____ ha
$V_{CORE}$	Size of wetland tract that is core area								_____ %
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"								_____ %
$V_{FREQ}$	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)								_____
<b>Transfer the data below from Data Form 2</b>									
$V_{POND}$	Percent of the wetland assessment area that ponds water								_____ %
$V_{STRATA}$	Number of vegetation strata								_____ strata
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils								_____ %
$V_{CEC}$	Percent difference in CEC in WAA (from Data Form 2)								_____ %
<b>Transfer the plot data below from Data Form 3 and average all values</b>									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha
$V_{TDEN}$									density = _____ stems/ha
$V_{SNAG}$									density = _____ stems/ha
$V_{TCOMP}$									concurrence = _____ %
$V_{COMP}$									concurrence = _____ %
$V_{SSD}$									density = _____ stems/ha
$V_{GVC}$									cover = _____ %
$V_{LITTER}$									cover = _____ %
$V_{OHOR}$									thickness = _____ cm
$V_{AHOR}$									thickness = _____ cm
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>									
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha

## Appendix B4

### Field Data Forms for Headwater Depression Wetlands

<b>Data Form</b>	<b>Number of Pages</b>	<b>Title</b>
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION**

**SUBCLASS: HEADWATER DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps and field reconnaissance as necessary to complete this sheet.

<b>HGM Variable Addressed</b>	<b>Procedure (see Chapter 6 for details)</b>	<b>Indicator Value</b>
$V_{FREQ}$ Flood frequency	Determine (or estimate) the frequency of flooding sufficient to generate outflow from the wetland.	Return interval = _____ (1 = annual flooding, 5 = once in 5 years)
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____ %
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____ %

**DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION**

**SUBCLASS: HEADWATER DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Walk the entire assessment area and develop estimates of the following indicators. For large or highly variable assessment areas, establish a series of transects across the area and make estimates along each transect, then average them for the area. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = _____
$V_{SOIL}$ Soil integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: HEADWATER DEPRESSION WETLANDS**

**WAA #** \_\_\_\_\_

**PLOT #** \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly-spaced transects. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	<p>Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m<sup>2</sup>/ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).</p> <p><b>Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.</b></p>	<p>Number of stems tallied = _____</p> <p>x conversion factor = _____</p>	<p>Total basal area = _____ m<sup>2</sup>/ha</p>

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____ _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____ _____	Average thickness of A horizon = _____ cm

**DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

**SUBCLASS: HEADWATER DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

**OBSERVATIONS WITHIN A 0.04-HA PLOT**

Field Procedure		
<p>(1) If tree cover is <math>\geq 20\%</math>, use the 50/20 rule and circle the dominant trees in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p>(2) If tree cover is <math>&lt; 20\%</math>, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p><b>A: Common dominants in reference standard sites</b></p>	<p><b>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</b></p>	
<i>Acer drummondii</i>	<i>Cephalanthus occidentalis</i>	
<i>Acer rubrum</i>	<i>Diospyros virginiana</i>	
<i>Fraxinus pennsylvanica</i>	<i>Forestiera acuminata</i>	
<i>Nyssa aquatica</i>	<i>Gleditsia aquatica</i>	
<i>Populus heterophylla</i>	<i>Planera aquatica</i>	
<i>Quercus lyrata</i>	<i>Ulmus americana</i>	
<i>Taxodium distichum</i>		
Calculations		
<p>Using the dominant species circled in Columns A and B above, calculate percent concurrence according to the following formula:</p> <p><math>\{[(1.0 * \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%</math></p>		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
<p><math>V_{TCOMP}</math> <math>V_{COMP}</math> Composition of woody vegetation strata</p>	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p align="center"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	<p>Percent concurrence:</p> <p><math>V_{TCOMP} = \underline{\hspace{2cm}} \%</math> <math>V_{COMP} = \underline{\hspace{2cm}} \%</math></p>



# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: HEADWATER DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

## **OBSERVATIONS WITHIN TWO 0.004-HA PLOTS**

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ $\times 125 =$ _____	Understory stems/ha = _____

## **OBSERVATIONS WITHIN 4 SUBPLOTS 1 m $\times$ 1 m SQUARE**

From the center point, measure 5 m in each cardinal direction and establish a 1-m  $\times$  1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

## **OBSERVATIONS ALONG TRANSECTS**

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, _____, _____, _____
	Transect 2	_____, _____, _____, _____

# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: HEADWATER DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

HGM Variable	Transfer the data below from Data Form 1								Enter this number in the FCI calculator spreadsheet
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA								_____ ha
$V_{CORE}$	Size of wetland tract that is core area								_____ %
$V_{FREQ}$	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)								_____
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"								_____ %
<b>Transfer the data below from Data Form 2</b>									
$V_{STRATA}$	Number of vegetation strata								_____ strata
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils								_____ %
<b>Transfer the plot data below from Data Form 3 and average all values</b>									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha
$V_{TDEN}$									density = _____ stems/ha
$V_{SNAG}$									density = _____ stems/ha
$V_{TCOMP}$									concurrence = _____ %
$V_{COMP}$									concurrence = _____ %
$V_{SSD}$									density = _____ stems/ha
$V_{GVC}$									cover = _____ %
$V_{LITTER}$									cover = _____ %
$V_{OHOR}$									thickness = _____ cm
$V_{AHOR}$									thickness = _____ cm
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>									
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha

## Appendix B5

### Field Data Forms for Isolated Depression Wetlands

<b>Data Form</b>	<b>Number of Pages</b>	<b>Title</b>
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION**

**SUBCLASS: ISOLATED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps, and field reconnaissance as necessary to complete this sheet. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

<b>HGM Variable Addressed</b>	<b>Procedure (see Chapter 6 for details)</b>	<b>Indicator Value</b>
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____ %
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____ %

**DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION**

**SUBCLASS: ISOLATED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Walk the entire assessment area and develop estimates of the following indicators. For large or highly variable assessment areas, establish a series of transects across the area and make estimates along each transect, then average them for the area. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation).

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = _____
$V_{SOIL}$ Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: ISOLATED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly spaced transects. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in m <sup>2</sup> /ha using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).  Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.	Number of stems tallied = _____  x conversion factor = _____	Total basal area = _____ m <sup>2</sup> /ha

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh ≥ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha = _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh ≥ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha = _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____	Average thickness of A horizon = _____ cm

**DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

**SUBCLASS: ISOLATED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

**OBSERVATIONS WITHIN A 0.04-HA PLOT**

Field Procedure		
<p>(1) If tree cover is <math>\geq 20\%</math>, use the 50/20 rule and circle the dominant trees in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p>(2) If tree cover is <math>&lt; 20\%</math>, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<b>A: Common dominants in reference standard sites</b>	<b>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</b>	
<i>Acer rubrum</i>	<i>Acer negundo</i>	
<i>Carya aquatica</i>	<i>Celtis laevigata</i>	
<i>Fraxinus tomentosa</i>	<i>Cephalanthus occidentalis</i>	
<i>Nyssa aquatica</i>	<i>Diospyros virginiana</i>	
<i>Populus heterophylla</i>	<i>Forestiera acuminata</i>	
<i>Quercus lyrata</i>	<i>Liquidambar styraciflua</i>	
<i>Quercus palustris</i>	<i>Planera aquatica</i>	
<i>Taxodium distichum</i>	<i>Ulmus americana</i>	
Calculations		
<p>Using the dominant species circled in Columns A and B above, calculate percent concurrence according to the following formula:</p> <p><math>\{[(1.0 * \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%</math></p>		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TCOMP}$ $V_{COMP}$ Composition of woody vegetation strata	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p align="center"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	<p>Percent concurrence:</p> <p><math>V_{TCOMP} = \underline{\hspace{2cm}} \%</math></p> <p><math>V_{COMP} = \underline{\hspace{2cm}} \%</math></p>

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: ISOLATED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

## **OBSERVATIONS WITHIN TWO 0.004-HA PLOTS**

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ $\times 125 =$ _____	Understory stems/ha = _____

## **OBSERVATIONS WITHIN 4 SUBPLOTS 1 m $\times$ 1 m SQUARE**

From the center point, measure 5 m in each cardinal direction and establish a 1-m  $\times$  1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

## **OBSERVATIONS ALONG TRANSECTS**

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters—just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters—just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____, _____, _____, _____
	Transect 2	_____, _____, _____, _____



# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: ISOLATED DEPRESSION WETLANDS**

**WAA #** \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

HGM Variable	Transfer the data below from Data Form 1	Enter this number in the FCI calculator spreadsheet							
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA	_____ ha							
$V_{CORE}$	Size of wetland tract that is core area	_____ %							
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"	_____ %							
<b>Transfer the data below from Data Form 2</b>									
$V_{STRATA}$	Number of vegetation strata	_____ strata							
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils	_____ %							
<b>Transfer the plot data below from Data Form 3 and average all values</b>									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha
$V_{TDEN}$									density = _____ stems/ha
$V_{SNAG}$									density = _____ stems/ha
$V_{TCOMP}$									concurrence = _____ %
$V_{COMP}$									concurrence = _____ %
$V_{SSD}$									density = _____ stems/ha
$V_{GYC}$									cover = _____ %
$V_{LITTER}$									cover = _____ %
$V_{OHOR}$									thickness = _____ cm
$V_{AHOR}$									thickness = _____ cm
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>									
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha

## Appendix B6

### Field Data Forms for Connected Depression Wetlands

Data Form	Number of Pages	Title
1	1	Tract-Level Data Collection
2	1	Wetland Assessment Area-Level Data Collection
3	3	Plot-Level Data Collection
4	1	Wetland Assessment Area-Data Summary
Please reproduce forms as needed.		

**DATA FORM 1 (1 page) - TRACT-LEVEL DATA COLLECTION****SUBCLASS: CONNECTED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

**Complete one copy of this form for each Wetland Assessment Area**

Use aerial photos, project descriptions, topographic maps and field reconnaissance as necessary to complete this sheet.

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{FREQ}$ Flood frequency	Determine (or estimate) the frequency of flooding due to backwater or overbank flows from streams for sites within the 5-year floodplain.	Flood return interval = _____ (1 = annual flooding, 5 = once in 5 years)
$V_{TRACT}$ Size of the forested wetland tract	From the aerial photos, measure the size of the assessment area and all contiguous forested wetland areas. To be considered "contiguous" an area must not be separated by open fields or highways, but rural gravel roads and streams are not to be regarded as significant breaks in continuity.	Size of the forested tract = _____ ha
$V_{CORE}$ Size of the wetland tract that is core area	From the aerial photo, calculate the percentage of the entire wetland tract that has at least a 300-m buffer from surrounding land uses. To do this, measure in 300 m from the perimeter of the entire forested area and draw a line. The portion of the wetland tract that lies inside this line is the core area. Divide the size of the core area by the size of the tract and multiply by 100.	Percentage of the tract that is core area = _____ %
$V_{CONNECT}$ Habitat connectivity	From the aerial photo, determine the percentage of the wetland tract perimeter that is accessible to other suitable habitats. Suitable habitats include upland forests, forested riparian areas, and other natural communities, including non-forested wetlands. They do not include farm fields, pastures, heavily grazed or farmed wetlands, isolated clusters of trees, fencerows, clearcuts, wooded subdivisions, etc. To calculate this value, identify the parts of the wetland tract perimeter that are within 0.5 km of suitable habitats. Divide the length of this perimeter zone by the total length of the wetland tract perimeter and multiply by 100. There is no need to calculate the perimeter or size of the other suitable habitats.	Percentage of the tract perimeter that is connected to other suitable habitats = _____ %

# DATA FORM 2 (1 page) - WETLAND ASSESSMENT AREA-LEVEL DATA COLLECTION

## SUBCLASS: CONNECTED DEPRESSION WETLANDS

WAA # \_\_\_\_\_

### Complete one copy of this form for each Wetland Assessment Area

Walk the entire assessment area and develop estimates of the following indicators. For large or highly variable assessment areas, establish a series of transects across the area and make estimates along each transect, then average them for the area. (NOTE: shaded variables are not used if they cannot be accurately assessed due to inundation.)

HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{STRATA}$ Number of vegetation strata present	Vegetation layers are counted as present in the following categories if they account for at least 10% cover over the observed area. <b>Canopy</b> (trees $\geq 10$ cm dbh that are in the canopy layer) <b>Subcanopy</b> (trees $\geq 10$ cm dbh that are below the canopy layer) <b>Understory</b> (shrubs and saplings $< 10$ cm dbh but at least 1.4 m (4.5 ft) tall) <b>Ground cover</b> (woody plants $< 1.4$ m (4.5 ft) tall, and herbaceous vegetation)	Number of strata present = _____
$V_{SOIL}$ Soil Integrity	Estimate the percentage of the site that has significantly altered soils. Normal farm tillage is not considered a significant alteration in this case, but fill, land leveling that removes surface horizons, and compacted areas such as roads are counted.	Percent of site with altered soils = _____
$V_{CEC}$ Cation Exchange Capacity (CEC)	For each altered area in the assessment area, determine the change in CEC and the area affected using the worksheet below. Base your estimates of CEC on the soil survey and/or the information in the table below (generally, use the midpoint of the CEC range - assume zero CEC for compacted areas such as roads). Record the summed results (from column 5, below) as a percentage indicating relative CEC change in the space at right.	Percentage change in CEC = _____ %

CEC Worksheet	Col. 1 CEC after alteration	Col. 2 CEC before alteration	Col. 3 Absolute Value of Col. 1 minus Col. 2	Col. 4 % of assessment area	Col. 5 Multiply Col. 3 $\times$ Col. 4
Altered Area 1					
Altered Area 2					
Altered Area 3					
SUM=					

### CEC Reference Table

Predominant Soil Texture or Map Unit Symbol	CEC Range (meq / 100 grams)	Midpoint of CEC Range (meq / 100 grams)
Sand	1-5	2.5
Fine Sandy Loam	5-10	7.5
Loam	5-15	10
Silt Loam	5-15	10
Clay Loam	15-30	22.5
Clay	30-150	90
Add other texture classes / map units		

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: CONNECTED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **PROCEDURE**

Establish a plot center, assign a plot number (above), and complete the following 3 data sheets as directed. Repeat with new sets of plot data sheets as needed, assigning a new plot number to each set. See Chapter 6 for sampling details and guidance regarding the number of plots required. Generally, small areas should be represented by at least 4 plots. For large areas, establish plot centers at paced distances along evenly spaced transects. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

### **OBSERVATIONS FROM THE CENTER POINT**

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{TBA}$ Basal area	Use a basal area wedge prism (or other basal area estimation tool) as directed, tally eligible tree stems and calculate basal area in $m^2/ha$ using the appropriate conversion factor for the prism (for example, for standard English 10-factor prism, multiply #stems tallied by 2.3).  Alternative method: If measuring individual tree stems with dbh tape or caliper, use worksheet in Appendix C to enter tree diameters and follow directions on that form to calculate basal area per hectare.	Number of stems tallied = _____  x conversion factor = _____	Total basal area = _____ $m^2/ha$

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Establish a circular plot with a radius of 11.35 m (37.24 ft) from the center point and make the following observations within the plot:

$V_{TDEN}$ Tree density	Count the number of trees (dbh $\geq$ 10 cm). Multiply by 25 to calculate stems/ha	# trees tallied = _____ x 25 = _____	tree density per ha = _____
$V_{SNAG}$ Snag density	Count the number of snags (standing dead trees at least 1.4 m (4.5 ft) tall and dbh $\geq$ 10 cm). Multiply by 25 to calculate snags/ha	# snags tallied = _____ x 25 = _____	snag density/ha = _____
$V_{OHOR}$ Thickness of the O horizon	Select two or more points within the plot that are representative of the range of microtopography within the plot as a whole. Dig a hole and measure the thickness of the O horizon (organic accumulation on the soil surface, excluding fresh litter, but including surface root mats if present) and the thickness of the A horizon (mineral soil with incorporated organic matter, indicated by distinct darkening relative to lower horizons)	Thickness of O horizon measurements (cm): _____ _____	Average thickness of O horizon = _____ cm
$V_{AHOR}$ Thickness of the A horizon		Thickness of A horizon measurements (cm): _____ _____	Average thickness of A horizon = _____ cm

# **DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION**

## **SUBCLASS: CONNECTED DEPRESSION WETLANDS**

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

### **OBSERVATIONS WITHIN A 0.04-HA PLOT**

Field Procedure		
<p>(1) If tree cover is <math>\geq 20\%</math>, use the 50/20 rule and circle the dominant trees in Columns A and B below (based on estimates of % cover by species). If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<p>(2) If tree cover is <math>&lt; 20\%</math>, identify the next tallest woody stratum with at least 10% cover. Use the 50/20 rule and circle the dominants in the next tallest woody stratum in Columns A and B below (based on estimates of % cover by species): If a dominant does not appear on the list, use local knowledge or literature to assign that species to the appropriate column.</p>		
<b>A: Common dominants in reference standard sites</b>		<b>B: Species commonly present in reference standard sites, but dominance generally indicates heavy selective harvest, land abandonment, or other disturbances</b>
<i>Acer rubrum</i>		<i>Celtis laevigata</i>
<i>Carya aquatica</i>		<i>Forestiera acuminata</i>
<i>Fraxinus pennsylvanica</i>		<i>Gleditsia aquatica</i>
<i>Nyssa aquatica</i>		<i>Planera aquatica</i>
<i>Quercus lyrata</i>		<i>Salix nigra</i>
<i>Taxodium distichum</i>		<i>Ulmus americana</i>
Office Procedure		
<p>Using the dominant species circled in Columns A and B above, calculate percent concurrence according to the following formula:</p> <p><math>\{[(1.0 \times \text{number of circled dominants in Column A}) + (0.66 * \text{number of circled dominants in Column B})] / \text{total number of circled dominants in all columns}\} \times 100 = \underline{\hspace{2cm}} \%</math></p>		
HGM Variable Addressed	Procedure (see Chapter 6 for details)	Indicator Value
$V_{TCOMP}$ $V_{COMP}$ Composition of woody vegetation strata	<p>If tree cover is <math>\geq 20\%</math>, record % concurrence in the <math>V_{TCOMP}</math> and <math>V_{COMP}</math> rows as a plot value.</p> <p align="center"><u>OR</u></p> <p>If tree cover is <math>&lt; 20\%</math>, record a "0" in the <math>V_{TCOMP}</math> row, and record % concurrence of the next tallest woody stratum in the <math>V_{COMP}</math> row.</p>	<p align="center">Percent concurrence:</p> <p><math>V_{TCOMP} = \underline{\hspace{2cm}} \%</math></p> <p><math>V_{COMP} = \underline{\hspace{2cm}} \%</math></p>

### DATA FORM 3 (3 pages) - PLOT-LEVEL DATA COLLECTION

#### SUBCLASS: CONNECTED DEPRESSION WETLANDS

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

#### OBSERVATIONS WITHIN TWO 0.004-HA PLOTS

From the center point, measure north and south 5 m and establish two circular subplots with a radius of 3.6 m (11.8 ft). Within each subplot, measure the following:

HGM Variable Addressed	Procedure (see Chapter 6 for details)		Indicator Value
$V_{SSD}$ Shrub/sapling density	Count the number of woody stems that are at least 1.4 m (4.5 ft) tall, but less than 10 cm dbh. Sum the tallies from both plots and multiply by 125 to get understory density per hectare	Subplot 1 tally = _____ Subplot 2 tally = _____ Sum = _____ × 125 = _____	Understory stems/ha = _____

#### OBSERVATIONS WITHIN 4 SUBPLOTS 1 m × 1 m SQUARE

From the center point, measure 5 m in each cardinal direction and establish a 1-m × 1-m square subplot. Within each subplot record the following:

$V_{LITTER}$ Litter cover	Estimate the percent of the plot area covered by undecomposed litter. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average litter cover = _____%
$V_{GVC}$ Ground vegetation cover	Estimate the percent cover of all herbaceous plants and woody plants < 1.4 m (4.5 ft) tall. Average the results of the 4 subplots.	Subplot 1 = _____% Subplot 2 = _____% Subplot 3 = _____% Subplot 4 = _____%	Average ground veg cover = _____%

#### OBSERVATIONS ALONG TRANSECTS

Establish two transects (each one 15.25 m or 50 ft) by stretching a tape from the center point in opposite cardinal directions (east and west). Within each transect, establish subtransects 3.65 m (12 ft) and 1.83 m (6 ft) long. Record the following:

$V_{WD}$ (1.83-m or 6-ft subtransects) Size Class 1 (small woody debris)	Count all intersections of sticks that are between 0.6 cm (0.25 in.) and 2.54 cm (1 in.) in diameter. Don't record diameters-just count.	# Small woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{WD}$ (3.65-m or 12-ft subtransects) Size Class 2 (medium woody debris)	Count all intersections of sticks that are between 2.54 cm (1 in.) and 7.6 cm (3 in.) in diameter. Don't record diameters-just count.	# Medium woody debris stems:
	Transect 1	# stems = _____
	Transect 2	# stems = _____
$V_{LOG}$ and $V_{WD}$ (15.25-m or 50-ft transects) Size Class 3 large woody debris (logs)	At each place where the tape intercepts a piece of dead wood on the ground that is at least 7.6 cm (3 in.) in diameter at the intercept point, measure and record the diameter of the stem in centimeters at the point of interception.	Stem diameters (cm)
	Transect 1	_____
	Transect 2	_____

# **DATA FORM 4 (1 page) - WETLAND ASSESSMENT AREA-DATA SUMMARY**

## **SUBCLASS: CONNECTED DEPRESSION WETLANDS**

**WAA #** \_\_\_\_\_

Transfer data from Data Forms 1 and 2 to this form, and also compile and summarize information from all copies of Data Form 3 in the appropriate spaces below. Attach additional copies if more than 8 plots are sampled within the Wetland Assessment Area. Enter the data on this form in the FCI Calculator Spreadsheet, or calculate FCI and FCU scores manually using the figures and formulae presented in Chapter 5. (Note: shaded variables are not used if they cannot be accurately assessed due to inundation.)

HGM Variable	Transfer the data below from Data Form 1								Enter this number in the FCI calculator spreadsheet
$V_{TRACT}$	Size of forested wetland that is contiguous with the WAA								_____ ha
$V_{CORE}$	Size of wetland tract that is core area								_____ %
$V_{CONNECT}$	Percent of wetland tract that is connected to "suitable habitat"								_____ %
$V_{FREQ}$	Flood recurrence interval in the WAA (1= annual, 5 = 1 year in 5)								_____
<b>Transfer the data below from Data Form 2</b>									
$V_{STRATA}$	Number of vegetation strata								_____ strata
$V_{SOIL}$	Percent of the wetland assessment area with culturally altered soils								_____ %
$V_{CEC}$	Percent difference in CEC in WAA (from Data Form 2)								_____ %
<b>Transfer the plot data below from Data Form 3 and average all values</b>									
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	<b>AVERAGES</b>
$V_{TBA}$									BA = _____ m <sup>2</sup> /ha
$V_{TDEN}$									density = _____ stems/ha
$V_{SNAG}$									density = _____ stems/ha
$V_{TCOMP}$									concurrence = _____ %
$V_{COMP}$									concurrence = _____ %
$V_{SSD}$									density = _____ stems/ha
$V_{GVC}$									cover = _____ %
$V_{LITTER}$									cover = _____ %
$V_{OHOR}$									thickness = _____ cm
$V_{AHOR}$									thickness = _____ cm
<b>Use the Woody Debris Calculator spreadsheet (or the worksheet in Appendix C) to generate log and woody debris volume based on the transect data on Data Form 3. Enter those values below and average.</b>									
$V_{LOG}$									log volume = _____ m <sup>3</sup> /ha
$V_{WD}$									wd volume = _____ m <sup>3</sup> /ha



# Appendix C

## Alternate Field Forms

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### CONTENTS

Alternate Data Form C1	Basal Area Determination Using Diameter Measurements
Alternate Data Form C2	Procedures for Manually Calculating Woody Debris and Log Volume

Please reproduce these forms as needed.

## USING DIAMETER MEASUREMENTS

**PLOT #** \_\_\_\_\_

Record the species (optional) and dbh (cm) of all trees (i.e., woody stems  $\geq 10$  cm or 4 in. dbh) in the 0.04-ha plot in Columns 1 and 2 in the table below. Complete the calculations (or use spreadsheet) to derive basal area per tree, and sum to get total plot basal area ( $\text{m}^2/\text{ha}$ ).

[illegible]

**Record Total Basal Area on Data Form 4 in the  $V_{TBA}$  row as a plot value**

**ALTERNATE DATA FORM C2 (2 pages) - PROCEDURES FOR MANUALLY CALCULATING  
WOODY DEBRIS AND LOG VOLUME**

SUBCLASS: \_\_\_\_\_

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

If you do not wish to use the spreadsheet provided in Appendix D to calculate woody debris and log volume for use in generating the  $V_{WD}$  and  $V_{LOG}$  variables, you can calculate the same summary data manually. Transfer the transect data recorded on Data Form 3 (Plot-Level Data Collection, Observations along Transects) to the data sheet below, and make the indicated calculations. Then transfer the results to the appropriate plot summary spaces on Data Form 4.

From Data Form 3, transfer the small woody debris stem counts (Size Class 1 - stems between 0.6 and 2.54 cm in diameter) for Transects 1 and 2, sum them, and multiply by 0.722 to convert to volume per hectare:

Stem Count, Transect 1 \_\_\_\_\_

Stem Count, Transect 2 \_\_\_\_\_

**total number of stems = \_\_\_\_\_  $\times$  0.722 = \_\_\_\_\_  $m^3/ha$ , Size Class 1**

From Data Form 3, transfer the medium woody debris stem counts (Size Class 2 - stems between 2.54 and 7.6 cm in diameter) for Transects 1 and 2, sum them, and multiply by 3.449 to convert to volume per hectare:

Stem Count, Transect 1 \_\_\_\_\_

Stem Count, Transect 2 \_\_\_\_\_

**total number of stems = \_\_\_\_\_  $\times$  3.449 = \_\_\_\_\_  $m^3/ha$ , Size Class 2**

From Data Form 3, transfer the diameter (cm) of each stem of Size Class 3 (large stems,  $> 7.6$  cm, or  $> 3$  in.) measured along Transect 1 and Transect 2 into the table below. Multiply each diameter measurement by 0.3937, and then square the result. Sum all results, then multiply that sum by 0.2657 to get large woody debris volume ( $m^3/ha$ ).

Transect 1			Transect 2		
1	2	3	1	2	3
Stem Diameter (cm)	Multiply stem diameter by 0.3937	Square the result in column 2	Stem Diameter (cm)	Multiply stem diameter by 0.3937	Square the result in column 2
<b>SUM=</b>			<b>SUM=</b>		

**ALTERNATE DATA FORM C2 (2 pages) - PROCEDURES FOR MANUALLY CALCULATING  
WOODY DEBRIS AND LOG VOLUME**

SUBCLASS: \_\_\_\_\_

WAA # \_\_\_\_\_

PLOT # \_\_\_\_\_

$V_{LOG}$

Sum of Size Class 3 Transect 1 + Sum of Size Class 3 Transect 2 = \_\_\_\_\_  $\times 0.2657 =$   
\_\_\_\_\_  $m^3/ha$ , Size Class 3

(Transfer this number as a plot value to the  $V_{LOG}$  row on Data Form 4)

$V_{WD}$

Sum of Size Class 1 \_\_\_\_\_  $m^3/ha$  + Size Class 2 \_\_\_\_\_  $m^3/ha$  + Size Class 3 \_\_\_\_\_  $m^2/ha =$   
\_\_\_\_\_  $m^3/ha$  (total woody debris volume/ha)

(Transfer this number as a plot value to the  $V_{WD}$  row on Data Form 4)

# Appendix D

## Spreadsheets

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### CONTENTS

- Appendix D1    Alternate Basal Area Calculation Spreadsheet (Figure D1)
- Appendix D2    Log and Woody Debris Calculation Spreadsheet  
                    (Figures D2-D3)
- Appendix D3    FCI/FCU Calculation Spreadsheet (Figure D4)

Note: This appendix contains demonstration printouts of these spreadsheets. Working copies are available for download at <http://www.wes.army.mil/el/wetlands/dataanal.html>.

## APPENDIX D1

[illegible]

**Figure D1. Example of the alternate basal area calculation spreadsheet**

## APPENDIX D2

Fill in Size Class 1 (stem count), Size Class 2 (stem count), and Size Class 3 (stem diameters in centimeters) in appropriate light green shaded areas below. Find resulting plot values for  $V_{LOG}$  and  $V_{WD}$  subindices in yellow shaded areas at the bottom of the sheet.

[illegible]

Figure D2. Example of woody debris calculation spreadsheet (Continued)



	Size Class 3 Sum of Stem Diameter <sup>2</sup> (in)		Size Class 3 Total Diameter <sup>2</sup> (in)	Size Class 3 tons/acre	Size Class 3 ft <sup>3</sup> /acre
	Transect 1	Transect 2			
Plot 1	0.0	0.0	0.0	0.0	0.0
Plot 2	0.0	0.0	0.0	0.0	0.0
Plot 3	0.0	0.0	0.0	0.0	0.0
Plot 4	0.0	0.0	0.0	0.0	0.0
Plot 5	0.0	0.0	0.0	0.0	0.0

Size Classes 1, 2, 3 tons/acre	Size Classes 1, 2, 3 ft <sup>3</sup> /acre
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0
0.0	0.0

$V_{LOG}$  and  $V_{WD}$  plot values can be found below:

Plot Number	( $V_{LOG}$ ) Size Class 3 m <sup>3</sup> /ha
Plot 1	0.0
Plot 2	0.0
Plot 3	0.0
Plot 4	0.0
Plot 5	0.0

Plot Number	( $V_{WD}$ ) Size Classes 1, 2, 3 m <sup>3</sup> /ha
Plot 1	0.0
Plot 2	0.0
Plot 3	0.0
Plot 4	0.0
Plot 5	0.0

Figure D2. (Concluded)



# APPENDIX D3

## FCI and FCU Calculations for the Flats Regional Subclass in the Arkansas Delta (Version 12/2001)

Project: \_\_\_\_\_

WAA# \_\_\_\_\_

Area of the WAA (ha): \_\_\_\_\_

In the green shaded cells below delete any existing numeric values and enter the WAA summary values from Data Form 4. Leave no cells blank. Print and attach this sheet to the Project Information and Summary of Assessment Form applicable to the project.

Variable	Metric Value	Units	Subindex
V <sub>AHOR</sub>		cm	0.000
V <sub>CEC</sub>	N/A	%	N/A
V <sub>COMP</sub>		%	0.000
V <sub>CONNECT</sub>		%	0.000
V <sub>CORE</sub>		%	0.000
V <sub>FREQ</sub>	N/A	years	N/A
V <sub>GVC</sub>		%	0.000
V <sub>LITTER</sub>		%	0.000
V <sub>LOG</sub>		m <sup>3</sup> / ha	0.000
V <sub>OHOR</sub>		cm	0.000
V <sub>POND</sub> (Holocene)		%	0.000
V <sub>POND</sub> (Pleistocene Alluvial Ter.)		%	0.000
V <sub>POND</sub> (Pleistocene Valley Train)		%	0.000
V <sub>SNAG</sub>		stems / ha	0.000
V <sub>SOIL</sub>		%	0.000
V <sub>SSD</sub>		stems / ha	0.000
V <sub>STRATA</sub>		# layers	0.000
V <sub>TBA</sub>		m <sup>2</sup> / ha	0.000
V <sub>TCOMP</sub>		%	0.000
V <sub>TDEN</sub>		stems / ha	0.000
V <sub>TRACT</sub>		ha	0.000
V <sub>WD</sub>		m <sup>3</sup> / ha	0.000

Function	Functional Capacity Index (FCI)	Functional Capacity Units (FCU)
Detain Floodwater	N/A	N/A
Detain Precipitation		
Cycle Nutrients		
Export Organic Carbon	N/A	N/A
Remove Elements and Compounds	N/A	N/A
Maintain Plant Communities		
Provide Wildlife Habitat		

Figure D3. Example FCI/FCU calculation spreadsheet

# Appendix E

## Spatial Data

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The following digital spatial data are available for downloading to assist in orienting field work, assembling project area descriptions, and identifying geomorphic surfaces and soils. The files are in ArcView format, and a copy of ArcExplorer is included in the download folder at [www.wes.army.mil/el/wetlands/datanal.html](http://www.wes.army.mil/el/wetlands/datanal.html) to allow access to the files. Some familiarity with ArcView is required to load and manipulate the digital information.

**ArcExplorer (program file)**

**Arkansas Roads**

**Cities and Towns**

**Delta Counties**

**Delta Hydrology**

**Delta Roads**

**Delta STATSGO soils**

**Wetland Planning Regions and Wetland Planning Areas**

**Geomorphology (Saucier 1994)**

# Appendix F

## Common and Scientific Names of Plant Species Referenced in Text and Data Forms

COMMON NAME	SCIENTIFIC NAME
swamp red maple	<i>Acer drummondii</i>
box elder	<i>Acer negundo</i>
red maple	<i>Acer rubrum</i>
silver maple	<i>Acer saccharinum</i>
leadplant	<i>Amorpha fruticosa</i>
paw-paw	<i>Asimina triloba</i>
river birch	<i>Betula nigra</i>
beautyberry	<i>Callicarpa americana</i>
ironwood	<i>Carpinus caroliniana</i>
water hickory	<i>Carya aquatica</i>
bitternut hickory	<i>Carya cordiformis</i>
pecan	<i>Carya illinoensis</i>
shellbark hickory	<i>Carya laciniosa</i>
shagbark hickory	<i>Carya ovata</i>
mockernut hickory	<i>Carya tomentosa</i>
catalpa	<i>Catalpa speciosa</i>
sugarberry	<i>Celtis laevigata</i>
buttonbush	<i>Cephalanthus occidentalis</i>
smooth dogwood	<i>Cornus drummondii</i>
flowering dogwood	<i>Cornus florida</i>
swamp dogwood	<i>Cornus foemina</i>
hawthorn	<i>Crataegus</i> spp.
persimmon	<i>Diospyros virginiana</i>
swamp privet	<i>Forestiera acuminata</i>
white ash	<i>Fraxinus americana</i>
green ash	<i>Fraxinus pennsylvanica</i>
water locust	<i>Gleditsia aquatica</i>
(Continued)	

COMMON NAME	SCIENTIFIC NAME
honey locust	<i>Gleditsia triacanthos</i>
hibiscus	<i>Hibiscus</i> spp.
deciduous holly	<i>Ilex decidua</i>
Virginia willow	<i>Itea virginica</i>
corkwood	<i>Leitneria floridana</i>
common privet	<i>Ligustrum</i> spp.
Pondberry	<i>Lindera melissifolia</i>
sweetgum	<i>Liquidambar styraciflua</i>
red mulberry	<i>Morus rubra</i>
water tupelo	<i>Nyssa aquatica</i>
blackgum	<i>Nyssa sylvatica</i>
loblolly pine	<i>Pinus taeda</i>
water elm	<i>Planera aquatica</i>
sycamore	<i>Platanus occidentalis</i>
eastern cottonwood	<i>Populus deltoides</i>
swamp cottonwood	<i>Populus heterophylla</i>
Chickasaw plum	<i>Prunus angustifolia</i>
black cherry	<i>Prunus serotina</i>
southern red oak	<i>Quercus falcata</i>
overcup oak	<i>Quercus lyrata</i>
cow oak	<i>Quercus michauxii</i>
water oak	<i>Quercus nigra</i>
Nuttall oak	<i>Quercus nuttallii</i>
cherrybark oak	<i>Quercus pagoda</i>
pin oak	<i>Quercus palustris</i>
willow oak	<i>Quercus phellos</i>
Shumard oak	<i>Quercus shumardii</i>
delta post oak	<i>Quercus similis</i>
post oak	<i>Quercus stellata</i>
black oak	<i>Quercus velutina</i>
blackberry	<i>Rubus</i> spp.
black willow	<i>Salix nigra</i>
elderberry	<i>Sambucus canadensis</i>
storax	<i>Styrax americana</i>
baldcypress	<i>Taxodium distichum</i>
winged elm	<i>Ulmus alata</i>
American elm	<i>Ulmus americana</i>
cedar elm	<i>Ulmus crassifolia</i>
blueberry	<i>Vaccinium</i> spp.

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<b>13. SUPPLEMENTARY NOTES</b>					
<b>14. ABSTRACT</b> <p>The Hydrogeomorphic (HGM) Approach is a method for developing and applying indices for the site-specific assessment of wetland functions. The HGM Approach was initially designed to be used in the context of the Clean Water Act Section 404 Regulatory Program permit review process to analyze project alternatives, minimize impacts, assess unavoidable impacts, determine mitigation requirements, and monitor the success of compensatory mitigation. However, a variety of other potential uses have been identified, including the design of wetland restoration projects, and management of wetlands.</p> <p>This Regional Guidebook presents the HGM Approach for assessing the functions of most of the wetlands that occur in the Delta Region of Arkansas, which is part of the Lower Mississippi River Alluvial Valley. The report begins with an overview of the HGM Approach and then classifies and characterizes the principal wetlands that have been identified within the Delta Region of Arkansas. Detailed HGM assessment models and protocols are presented for six of those wetland types, or subclasses, representing all of the forested wetlands in the region other than those associated with lakes and impoundments. The following wetland subclasses are treated in detail: Flat, Mid-gradient Riverine, Low-gradient Riverine Backwater, Low-gradient Riverine Overbank, Headwater Depression, Isolated Depression, and Connected Depression. For each wetland subclass, the guidebook presents (a) the rationale used to select</p> <div style="text-align: right;">(Continued)</div>					
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the wetland functions considered in the assessment process, (b) the rationale used to select assessment model variables, (c) the rationale used to develop assessment models, and (d) the functional index calibration curves developed from reference wetlands that are used in the assessment models. The guidebook outlines an assessment protocol for using the model variables and functional indices to assess each of the wetland subclasses. The appendices provide field data collection forms, spreadsheets for making calculations, and a variety of supporting spatial data intended for use in the context of a Geographic Information System.

## **15. (Concluded)**

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Clean Water Act  
Functional assessment  
Geomorphology  
Hydrogeomorphic (HGM) Approach  
Hydrology  
Impact assessment  
Lower Mississippi River  
Mississippi Alluvial Valley  
Mississippi Valley  
Mitigation  
National Action Plan  
Reference wetlands  
Wetland  
Wetland assessment  
Wetland classification  
Wetland function  
Wetland restoration